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Original Articles

THE EQUILIBRATION OF OCCLUSION IN ORTHODONTICS

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INTRODUCTION

To seek refuge in the idea that defects in occlusal balance are self-rectifying in time is to indulge in wishful thinking.

An approach to the study of dental occlusion cannot be made solely from one point of view of one group only. The orthodontist, the prosthodontist, and the periodontist all contribute to the sum total of the knowledge of dental occlusion.

For years there has been an exchange of ideas among these groups. For example, I have heard Dr. Tweed say his own philosophy of orthodontic treatment was developed, to a considerable degree, from ideas contributed by his friends among the prosthodontists, which ideas he then complemented with his own knowledge of prosthodontics. In like manner, the periodontists have made contributions to orthodontics. In this thesis, it is my desire to demonstrate that we in orthodontics could profit by the knowledge and procedures developed by the periodontists in regard to occlusal correction. By the application of their methods of selective spot grinding, we could probably eliminate the possibility of injury brought about by traumatogenic occlusion and procure, in addition, better retention by a more ideal functional occlusion.

A comprehensive study of the occlusion of natural teeth is such an extensive subject that even an attempt to present this single phase of occlusal correction becomes very much involved.

The subject of occlusion is one which is very timely, however, because balanced occlusion is continuously receiving more attention at the hands of the prosthodontist, the periodontist, and the orthodontist.

This thesis was submitted to the American Board of Orthodontics in partial fulfillment of the author's requirement for certification.

OCCLUSION

It is said, and correctly so, that occlusion is the purpose of all dentistry. The objective of every phase of dental practice is to procure and maintain functional occlusion without injury to the periodontium. The correction of abnormal occlusal stresses necessitates a knowledge of what normal should be. Therefore, before proceeding further we should first know what normal really means.

The term occlusion refers to the manner in which the maxillary and mandibular teeth meet during the functional excursions of the mandible. The uniformity of the appearance of this phenomenon in nature is referred to as the "law of occlusion." The Committee on Nomenclature of the American Dental Association defines occlusion as: "the contact of the teeth of both jaws when closed or during those excursive movements of the mandible which are essential to the function of mastication."

The ideal occlusion, one in which 138 points on the surfaces of the teeth occlude in a definite manner, had long been the standard of normal to the orthodontist. This hypothetical "ideal" was derived by Edward H. Angle from his studies of the morphology of the teeth, but in recent years leading orthodontists have challenged and severely criticized strict adherence to an "ideal" normal. According to Hellman, it has no biologic justification and no scientific foundation nor has it ever been found in nature.

Definitions of normal occlusion range from that of Dr. Angle's, "the normal relations of the occlusal inclined planes of the teeth when the jaws are closed," to that of Dr. Strang's which is probably the most comprehensive and all-inclusive. He defines it as: "that structural composite consisting, fundamentally, of the teeth and jaws and characterized by a normal relationship of the so-called occlusal incline planes of the teeth that are individually and collectively located in architectural harmony with their basal bones and with cranial anatomy, exhibit correct proximal contacting and axial positioning and have associated with them, a normal growth, development, location and correlation of all environmental tissues and parts."

Approaching the subject of occlusion now from the physiologic point of view, we note that when the periodontium is able to withstand the forces of occlusion without the initiation of pathologic changes in the periodontal membrane, we say a physiologic occlusion exists. H. K. Box defines it as: "condition in which the systems of forces, acting upon the tooth during occlusion, are in a state of equilibrium and do not and cannot change the normal relationship existing between the tooth and its supporting structures." Physiologic occlusion is manifested, clinically, in two forms according to Box:

1. Vertical Loading: occurs when the occlusal force is exerted in the direction of the long axis of the tooth.

2. Horizontal Loading: occurs when the occlusal force is exerted in a direction oblique to the long axis of the tooth.

When the state of equilibrium between the forces acting upon the tooth and the resultant of the periodontium ceases to exist, traumatic occlusion results. This condition is defined by Miller as: "the abnormal occlusal stress

capable of producing, or which is producing, an injury to the periodontium and often to the pulp.'' It, likewise, is manifested in two forms: vertical overloading and horizontal overloading.

Defining occlusion according to the functional relationship of the teeth, we see that centric occlusion exists when the mandible is in a position from which lateral excursions can be initiated. Eccentric occlusion is any functional relationship of the jaws outside of centric. In centric position the condyles of the mandible are not in the most retruded position possible in the glenoid fossa, but the most retruded position from which lateral movements are possible. With considerable effort, the condyles can be retruded just a little more but not sufficiently to create, ''a dual bite,'' that is, distally a half cusp or more.

Balanced occlusion, as interpreted by the orthodontist and the periodontist, differs considerably from that of the prosthodontist. The latter may attain a balanced occlusion in his artificial denture when only three distributed points are in contact, because uniform pressure is transmitted to the entire upper and lower ridges by means of the balance of stress on the dentures. This does not hold true in the natural dentition because the teeth are anchored independently of each other; therefore, the stress is solely on the teeth in contact. For this reason, and to differentiate further this difference, we shall use the terms equilibrated stress and equilibration of occlusion when referring to the so-called ''balance of occlusion'' in natural dentures.

We may, therefore, define an equilibrated occlusion as: ''that normal balanced occlusion of the natural dentition in which each and every individual tooth unit of the maxillary and mandibular dentures makes continuous occluding contact with at least one and no more than two opposing units through every functional occluding range of denture relationship.''

''So very important and essential is the normal action of the incline planes of all the opposing teeth,'' writes James D. McCoy, ''that the statement may almost be made that teeth, in their normal relations, remain in that relationship (providing the other functional forces incident to occlusion are likewise harmonious) while teeth occluding other than in their normal relationship continue, through the force of the incline planes, to maintain their state of abnormal occlusion.'' Hence, the importance in orthodontic treatment of establishing every tooth of both arches in the relationship intended by Nature where it will fully function and aid in maintaining the complete integrity of the masticatory apparatus.

A full appreciation of the cuspal relations of the teeth is of prime importance to the orthodontist, for the action of the inclined planes of the cusps of the opposing teeth constitutes one of the important forces which keep the teeth in their normal occlusion, when once they have been established in that relationship, either through normal growth or by orthodontic means.

PHYSIOLOGY OF MASTICATION

A. Types of Mastication.—Through evolution four main types of mastication have emerged:

1. Carnivorous: In this type the temporomandibular articulation operates almost as a pure hinge joint. The teeth are so shaped as only to cut and tear.

2. Herbivorous: Possess lateral movements, so teeth are broad with sagittal cutting blades for lateral cutting and grinding.

3. Rodent: Typified by having buccolingual cutting blades designed for cutting during anteroposterior movements.

4. Omnivorous: This type combines the features and movements of the other three types. It is to this class that man belongs.

The shape of the upper and lower molars and their functional cooperation demonstrate that balanced occlusion is man's evolutionary heritage. However, during the development of the individual, nutritional factors, abnormal habits, or any number of unknown factors may suppress this heritage and lead to an unbalanced occlusion.

B. Types of Masticating Derangements.—These are of three kinds:

1. Interference with lateral and protrusive movements. Cuspal interference causes shorter and more vertical movements of the jaw in the shearing stroke and in extreme cases leads to a "locked bite." If permitted to continue for a long period of time, unnatural tooth wear and periodontal injury will result.

2. The performance of masticating function in an eccentric relationship (McLean "convenience relationship"), a compensating adjustment by the patients to occlusal interference in centric, is often seen in some types of malocclusions.

3. Centric interferences observed when the dentures strike on cusp ridges before sliding into centric position with potential damage to the bone from the resulting anteroposterior thrust.

C. Physiologic Occlusion.—The attainment and maintenance of physiologic occlusion should be the aim of all dentists, whether a general practitioner or specialist. It is defined by H. K. Box as, "a condition in which the systems of forces, acting upon the tooth during occlusion, are in a state of equilibrium and do not, and cannot, change the normal relationship existing between the tooth and its supporting structures." In other words, physiologic occlusion is present when the periodontium is able to withstand the forces of occlusion without an initiation of pathologic changes in the periodontal membrane. As previously mentioned under "Occlusion" physiologic occlusion is manifested clinically in two forms:

1. Vertical loading: Which occurs when occlusal force is exerted in the direction of the long axis of the tooth.

2. Horizontal loading: Occurs when occlusal force is exerted in a direction oblique to the long axis of the tooth.

In both vertical and horizontal loading, the occlusal pressure against the tooth is balanced by the resistance of the periodontal tissues resulting in a normal distribution of forces.

3. Normal distribution of force: "When a normal occlusion exists, each and every individual tooth unit of the maxillary and mandibular dentures makes continuous occluding contact with at least one, and no more than two, opposing units through every functional occluding range of denture relationship."[19] This statement simply means that there is no such thing as cusp interference where a normal arrangement of teeth exists.

"When it is realized that cusp interference is not only directly responsible for traumatized peridental structures, but is also indirectly responsible for the disuse atrophy associated with those teeth which do not participate in the interference, and that cusp interference is often one of the contributing factors and, in a sense, the principal factor responsible for many pathological conditions in the temporomandibular joint, then the value of normal arrangement of teeth is more fully appreciated."[19]

Cusp interference simply means interference with a just and equitable distribution of masticatory force. "Normal arrangements of the maxillary and mandibular teeth and the normal correlation of the two dentures result through the medium of cusp interdigitation in lateral excursions of the mandible in a just and equitable distribution of masticatory force, which distribution cannot be maintained where cusp interference exists. Where normal occlusion exists during the functional range, protrusive to centric, the force of mastication is justly and equitably distributed as pressures in the peridental membranes of all the teeth. Cusp interference prevents equitable distribution in both protrusive to centric and lateral to centric excursions and results, indirectly,"[19] in disuse atrophy and traumatized areas with eventual earlier loss of the teeth than would otherwise be the case.

"The term, 'moment of force,' refers to the turning effect of a force and is the product of a force and its perpendicular distance from the fulcrum. Trauma is not necessarily caused directly by masticatory force itself, but indirectly by the moment of the individual forces which exist as a result of the division and distribution of masticatory force and by the application and angle of application of these individual forces, one of which is associated with each and every occluding contact.

"Fig. 1 is offered to assist in the explanation and application of moments of force. This drawing represents an upper bicuspid and its surrounding structures. The point *A* is the point of application of an individual force occasioned by occlusal contact with an opponent when extreme functional lateral occlusion exists.

"First, let us suppose that the distribution of masticatory force is just and equitable and that the magnitude of the force applied at this point is one of 15 units. The magnitude and direction of application being represented by the arrow *AB*. This force, being applied at an angle to the surface, is resolved in two forces. The one around which our interest now centers is represented, both in direction and magnitude, by the arrow *AC*. This force is at right angles to the surface and, let us say, has a magnitude of 10 units. Its perpendicular

distance from *F*, the selected fulcrum, is a distance of 12 units. The moment of force *AC*, or its turning effect upon the lines (the tooth) is represented by the figure 120.

"Now, let the point *A′* be the point of application of the individual masticatory force when the relationship known as centric occlusion exists.

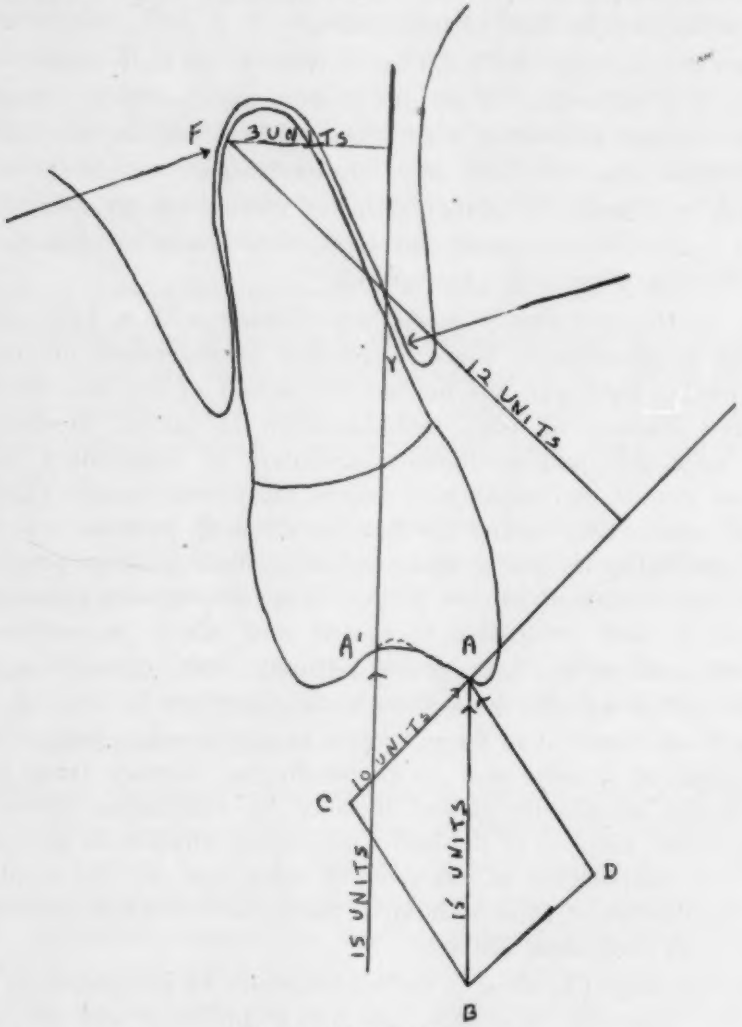

Fig. 1.—After Maxwell.

"Let us suppose that the direction of application to the surface of the marginal ridge is at right angle to that surface and that the magnitude of 15 units prevails. This force, being applied at right angles, is not resolved into component forces, but in its effectiveness acts as a single force. Owing to the direction of this force, which does not coincide with the theoretical long axis of the tooth or the lever which now prevails, the perpendicular distance from the fulcrum is one of 3 units and hence, the moment of this individual masticatory force is represented by the figure 45. We, therefore, see that the moment of force, prevailing at lateral occlusion, is much greater than that at centric occlusion.

"Now, let us suppose that an unjust and inequitable distribution prevails (as would in the case of an elongated tooth) and that the magnitude of the force applied, at the point *A*, is one of 75 units. Maintaining our same proportions, the force *AC* now has a magnitude of 50 units and its moment is represented by the figure 600. Let us now transfer our calculations to the point *A′* and suppose that as this position is approached, by the point of application during mandibular movement, the magnitude is reduced from 75 units to one of 15 units. We are justified in this supposition owing to the fact that even in a malocclusion a fair degree of equitable distribution prevails at centric relationship. With this hypothetical basis of calculation, the moment of force at *A′* is 45, even though we are dealing with a malocclusion.

"Now, before we proceed further with these figures in mind, it seems logical to conclude: first, that the pressures engendered and the extensions of the peridental fibers, where a moment of 120 prevails, are within the tolerable physiological limits, and hence, that health would prevail; secondly, that the pressures and over extensions which accompany a moment of 600 are beyond the limit of the safety factors and that trauma must result with its chronic inflammation"[19] and subsequent degenerative steps.

"Let us now consider the tooth leverages involved. The point *F* was arbitrarily selected as the fulcrum. This selection is permissible because, when three forces act upon an object, the point of application of any one of the three can be thought of as a fulcrum, and the other two as the resistance and effort. One should recognize that, when the force *AC* becomes operative and the lever (the tooth) begins to turn in its socket, a force is engendered at the point *Y*, the direction of which is represented by the arrow; also, that a force becomes operative at the point *F*, the direction of which is represented by the arrow *F*. The force *AC*, then becomes the effort of the lever, the *Y* the resistance and *F* the fulcrum, which condition gives us a second class lever with its mechanical advantage.

"Now, suppose that trauma has existed until such time that alveolar absorption has taken place resulting in a shortening of the resistance arm with the proportional increase in mechanical advantage. Under such a condition one can readily understand why the ravages of pyorrhea have been so difficult to cope with, if for no other reason than because of the mechanics involved."[19]

D. Traumatic Occlusion.—Though previously defined under "Occlusion," we submit here Box's definition of traumatic occlusion because it gives a mechanical picture: "a condition in which the system of forces acting upon the tooth during occlusion is not in equilibrium."

As in physiologic occlusion, traumatic occlusion is manifested principally in two forms: vertical and horizontal overloading.

1. Vertical overloading: Present when the occlusal force is applied in the direction of the long axis of the tooth, to such a degree that the compressal stress on the periodontal membrane, at the apex, is so excessive as to produce injury to the periodontal tissues. Such a condition is readily detected by a radiographic examination.

2. Horizontal overloading: Manifested when the occlusal force is exerted in a direction oblique to the long axis of the tooth. This force may be resolved into a vertical force, acting along the axis, and a horizontal one at right angles to it.

This horizontal force produces an abnormal torque which creates overstress in the periodontal membrane of the gingival third. On the side away from the point of application of the force (the push side), it is one of compression, and in the same gingival third on the side of force (the pull side), it is one of tension.

3. Box's classification of traumatic occlusion: Excessive occlusal stress, with resulting injury to the periodontal tissues, is dependent upon a disturbed relationship between the occlusal force applied and the limits of resistance of the periodontium.

H. K. Box classified traumatic occlusion in the following three groups, according to the mode of origin:

> a. Primary: "Abnormal occlusal factor with normal periodontal factor." The occlusal force is so excessive as to cause injury to the periodontal membrane. It is this class of traumatic occlusion with which the author is primarily concerned in this thesis, for under this classification we find the principal cause to be cuspid interference, unbalanced occlusion, uneven or excess wear, faulty restoration, and dental anomalies.
>
> Cuspal interference, due to failure in obtaining a balanced occlusion in centric relation or a balanced articulation in lateral excursions upon completion of orthodontic treatment, will receive special attention later.
>
> b. Secondary: "Normal occlusal factor with abnormal periodontal factor." Overstress is produced due to a subnormal periodontium though the occlusal stress may be normal.
>
> c. Combined: "Abnormality in both occlusal and periodontal factors." We orthodontists may err here by leaving a tooth in slight supraversion after having moved it a considerable distance. We then have created a condition whereby we have cuspal interference in a tooth with a weakened periodontium due to the excessive movement.

4. Abnormal Distribution of Force:[19] One of the commonest individual applications of forces associated with trauma is illustrated in Figs. 2 and 3.

"The condition which these illustrations attempt to depict is one that permits a multitude of variations and in Fig. 2 is the result of improper interdigitation. Fig. 3 shows correct interdigitation and the resultant of the two forces applied to the upper bicuspid as lateral relationship, which condition also exists, with slight modification at centric relationship, is approached and reached.

"The two forces applied by the two lower opponents are shown by the arrows *A* and *D*. The force *D*, being of the greater magnitude, is applied by the lower second bicuspid. These forces are each resolved into two forces, one each of which acts at right angles to the surface of the mesial and distal slopes, and which cross at the point *G*. The magnitude of these latter two is shown by the length of *AC* and *DF*. Drawing in the parallelogram *GHMI* gives us a resultant of *GM*, the effective force on the upper bicuspid, which has but a small

moment of force owing to the short perpendicular distance *OP* from the fulcrum, which in this instance would approximate the apex of the upper bicuspid. It is such a force that causes teeth to tip or incline mesially around the dental arch up to, and including, the cuspids. These forces, taken collectively, constitute the force which results in the condition around the lower cuspids so frequently spoken of as 'being due to the presence and eruption of the lower third molars.' The magnitude of the eruptive force, which brings a tooth into correct or incorrect arch position, is so slight, compared to the magnitude of a masticating force, as to be practically negligible. This force *GM* is what is

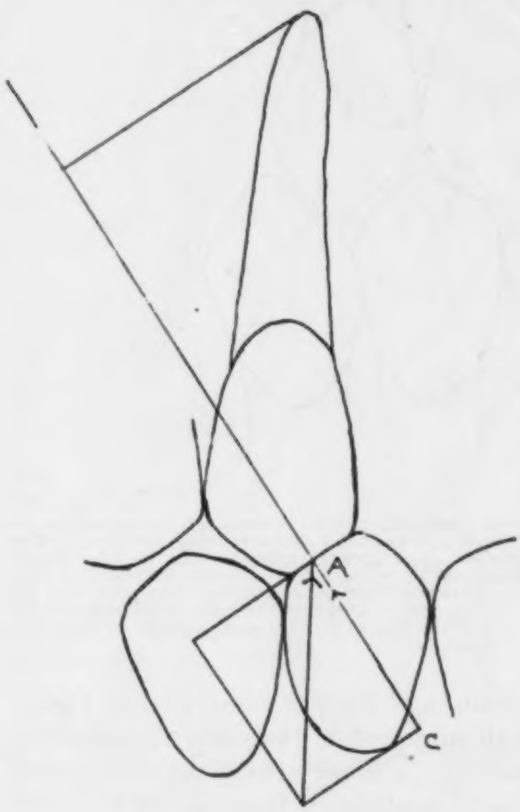

Fig. 2.—After Maxwell.

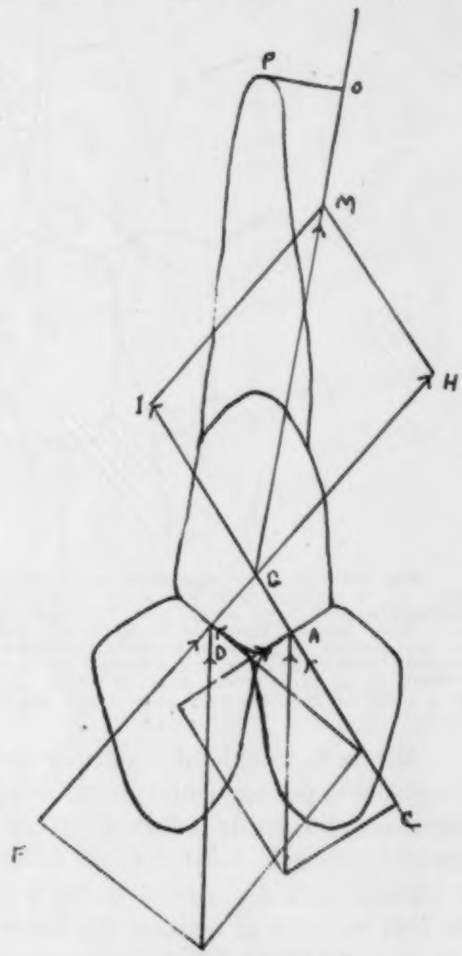

Fig. 3.—After Maxwell.

sometimes called the 'anterior resultant' of masticatory force for obvious reasons. This force is modified, to a certain extent, in the individual components of the upper denture, by the presence of tight contacts, but the 'anterior resultant,' taken collectively, constitutes a definite problem,''[19] the results of which become evident when the anterior segments begin to buckle after all retention is removed upon ''completion of our orthodontic cases.'' (See also Fig. 4.) This condition is seen in its most severe stage in the bimaxillary protrusion cases we orthodontists see so frequently.

"Now, suppose that an incorrect interdigitation exists, such as is shown in Fig. 2. The anterior component is missing and the moment of the operative force is great owing to the perpendicular distance from the fulcrum. The tooth moves out of the way of this force each time occlusion takes place and the magnitude of the force, let us say, is not histologically compatible with the intent and purpose of nature. Such conditions result in the peridental membranes being overwhelmed."[19]

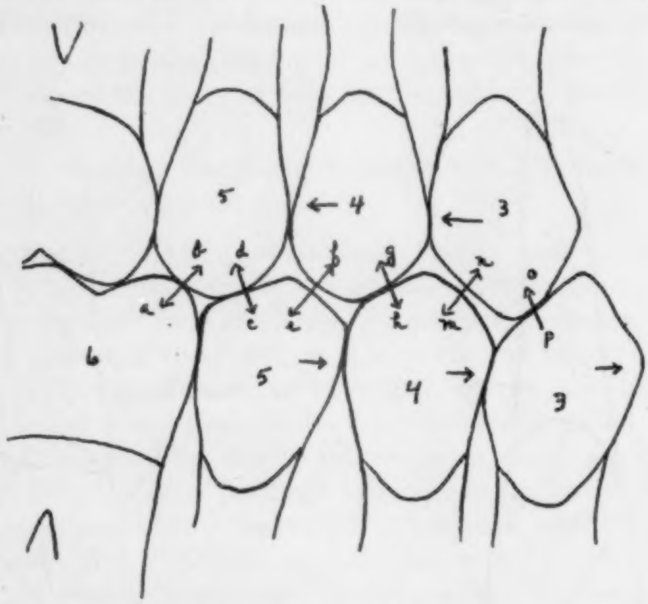

Fig. 4.—Force *ab* approximately equals *cd* balancing *U5*. Force *ef* is nonexistent. Force *gh* is greater than forces *ab* or *cd* and thus prevents *U4* from moving mesially. The resultant mesial force of *L5* plus force *gh* exerts an even greater mesial force to *L4*. Force *mn* is nonexistent. Force *op* is exerting a mesiolingual force on *L3*, especially in lateral eccentric movements of the jaw, which in addition to aforementionel mesial forces from *L4* and *L5* can very likely result in the eventual collapse of the lower anterior segment with subsequent overlapping of these lower anterior teeth. (A plausible diagrammatic explanation of why the lower anterior segment may buckle and not the upper.)

Another example of abnormal distribution of force is illustrated in Fig. 5, where the opposing dental units, although subjected to the same magnitude of force, are differently affected. Here we see "a lower second molar standing vertically, its axis parallel to the direction of masticatory force, shown by arrow *A*. The opposing upper tooth has a decided buccal inclination, its lingual cusp fits into the central fossa of the lower second molar so that the lingual surface was in contact with the lingual cusp of the lower molar. The magnitude of the masticating force applied to the upper tooth is comparatively great, owing to the mandibular leverage involved. The moment of force (measured by magnitude of arrow *XB* times the perpendicular distance *BC*) as far as the upper tooth is concerned is great, whereas the moment of force associated with the lower molar, as illustrated by the resultant of the parallelogram, is parallel to the long axis of the tooth and, therefore, its moment of force is practically nil."[19] We see then that the periodontium of the lower molar is not traumatized, while its opponent, due to its axial inclination, suffers tremendously.

It is hoped that these schematic drawings will more clearly demonstrate the great importance of placing all the teeth upright on basal bone in order to secure a balanced and lasting occlusion, the goal of all orthodontic treatment.

To illustrate an idea more clearly, all the drawings have been purposely exaggerated.

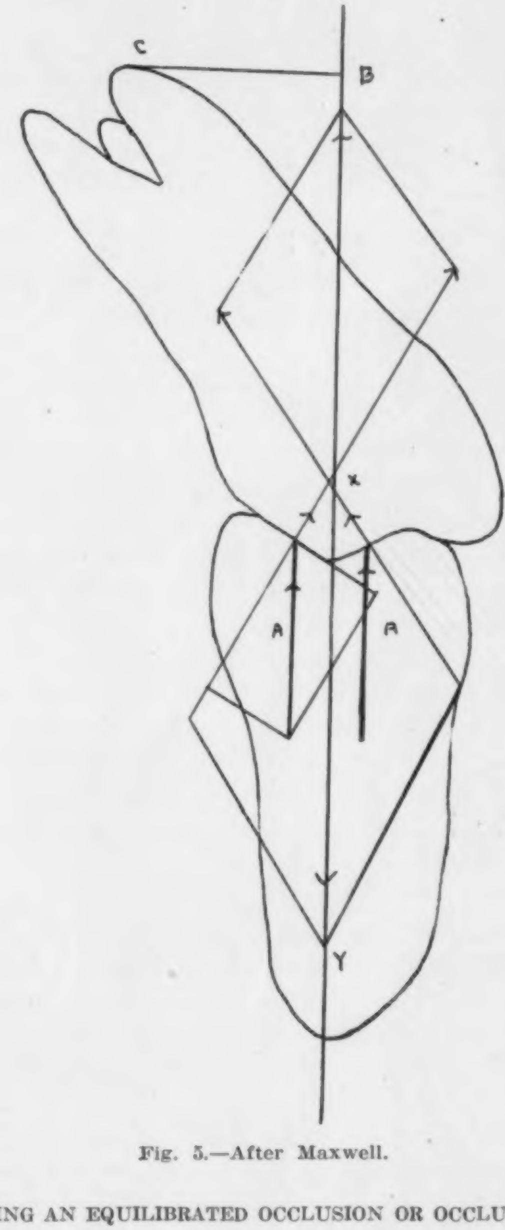

Fig. 5.—After Maxwell.

ESTABLISHING AN EQUILIBRATED OCCLUSION OR OCCLUSAL BALANCE

Each and every tooth in the natural dentition is, or is capable of being, mechanically arranged to withstand normal occlusal forces. Each tooth, or group of teeth, is so shaped to perform a definite function in mastication. When the occlusal force applied is in equilibrium with the resistant forces of the

periodontal tissues, a physiologic occlusion exists. However, a number of factors may upset such an ideal relationship, producing, in time, a pathologic condition. These factors may be purely local, systemic, or a combination of both. I am confining myself, in this thesis, to the local factors, especially those which can be eradicated by selective spot grinding, the objective: (1) eliminating premature contacts and (2) securing simultaneous contact, so that the load may be distributed over as many teeth as possible.

A tooth which may be in apparently good relationship in centric occlusion can be in trauma in an eccentric position when it attempts to carry the load intended for several teeth, and sooner or later it will show signs of traumatic occlusion.

A. Methods of Attaining an Equilibrated Occlusion.—

1. By detailed positioning of individual teeth: The orthodontist has an advantage over his fellow dentists since he has additional methods at his disposal for the attainment of an equilibrated occlusion. He can secure the detailed positioning of the individual teeth by use of orthodontic appliances. If he uses the edgewise appliance, or some similar multibanded technique, which gives him complete control over each and every tooth in the dental arch, he can position the teeth upright on basal bone so that the resultant of the occlusal forces is directed along the long axis of the teeth, or nearly so. Great detail of positioning of individual teeth is possible with a carefully placed and manipulated edgewise appliance. A tooth that may be in supraclusion, and thus in traumatic occlusion, can easily be depressed into the line of occlusion; one that may otherwise be in infraclusion can easily be raised. Should a single cusp be in supraclusion, by proper torqueing of the arch wire the elongated cusp can usually be depressed and brought into the line of occlusion. Enumerating these various means of positioning individual teeth is merely for the purpose of illustrating how an orthodontic appliance can be a most beneficial aid in securing an equilibrated occlusion and is not intended as a glorification of any particular appliance.

An excellent supplement to the proper use of an orthodontic appliance, for the attainment of the near ideal in a balanced occlusion, is the velum rubber "positioner."[20] This is a soft rubber "bite" similar to that worn by fighters in the boxing ring. It is processed on the "ideal setup," made from the plaster casts of the patient's own teeth, on which the individual teeth have been cut off and repositioned on the dental ridge (in wax) to a position of ideal occlusion, both esthetically and functionally.

When properly and carefully constructed and diligently worn by the patient, as directed by the orthodontist, the positioner has been found to be an excellent supplemental appliance for accomplishing the detailed positioning of the individual teeth. It also greatly minimizes the amount or the need for selective spot grinding.

2. By selective spot grinding: No matter how much care and time are consumed in the detailed positioning of the teeth, it is my opinion that most if not all orthodontically corrected occlusions require careful and selective spot

A.

C.

D.

Fig. 6.

A.

B.

C.

D.

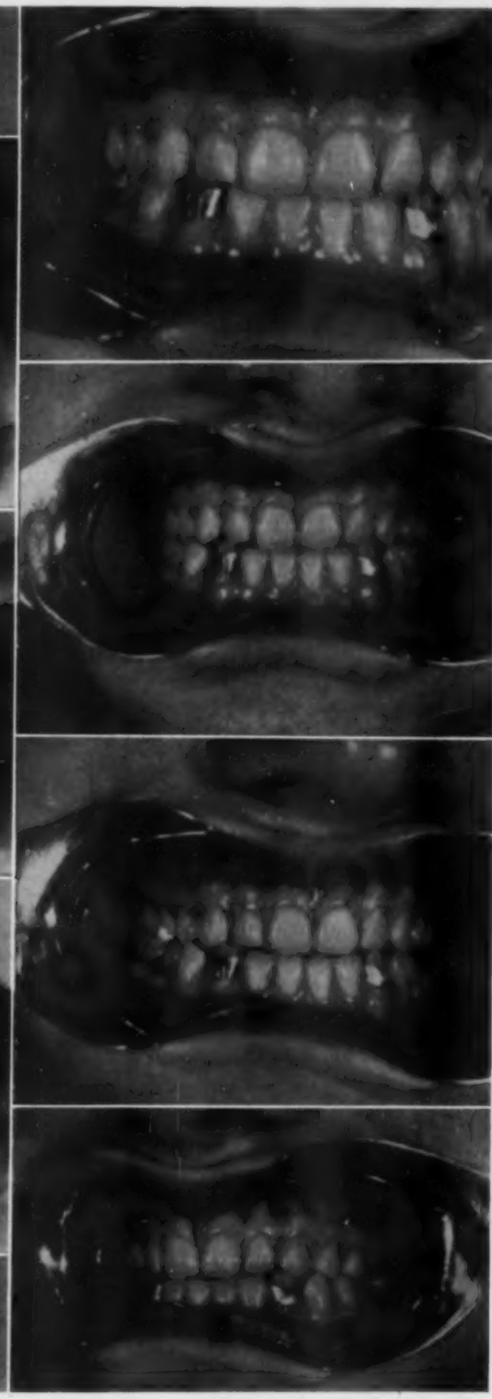

Fig. 7.

Fig. 6.—*A*, *C*, and *D*, Pregrind. Only cuspids contact on working side in right and left eccentric.

Fig. 7.—*A*, *B*, *C*, and *D*, Postgrind. (Same case as Fig. 6.)

grinding in order to establish more closely the ideal arrangement of the teeth, whereby stresses on all the teeth are innocuously distributed in all functional positions of the jaws. When such occlusal adjustments are accomplished properly, this should preclude the possibility of traumatic occlusion developing and likewise aid materially in the maintaining of the desired retention.

Frequently a tooth which seems to be in good relation in centric occlusion is subjected to trauma in lateral excursion. Cuspids, especially those with long, pointed cusps, are frequent offenders in eccentric occlusion (Fig. 6). Such cuspid interference can very easily be the primary factor in the buckling of the teeth in the anterior segment upon removal of the retaining appliance, if not before. This is more evident, diagrammatically, in Fig. 4.

By careful grinding we allow more teeth to assume the load carried by the traumatized tooth and thereby relieve the traumatic condition and create a better masticatory apparatus. For example, if in the right lateral excursions only the cuspids hit, then these two teeth are carrying 100 per cent of the load between them. If, then, by proper spot grinding, the two first premolars are also brought into contact in right eccentric, then each occluding point is carrying 50 per cent of the load. If, through spot grinding, ten points are brought into occlusal contact, then each contact point is carrying 10 per cent of the load.

We would attain the ideal in equilibrated occlusion if all opposing teeth would simultaneously contact their antagonists, when the jaws are in centric and in every functional relation. This is not, however, essential to physiologic occlusion, but the closer we come to producing the ultimate in equilibrated occlusion the more stable will be our orthodontic results.

Schuyler[16] mentions seven ideals to be attained in equilibrated occlusion:

1. Maximum distribution of stress in centric relation.
2. Retention of the maxillomandibular opening.
3. Harmony of grinding inclines, thereby distributing eccentric occlusal stresses.
4. Reduction of the inclines of guiding tooth surfaces, that occlusal stresses may be more favorably applied to the supporting tissues.
5. Retention of sharpness of cutting cusps.
6. Increase of food exists.
7. Decrease of contact surfaces.

B. Prerequisites to Spot Grinding.—In selective spot grinding of the teeth, as in many other scientific procedures, certain prerequisites are essential before embarking upon a carefully planned procedure. The prerequisites are:

1. Radiographs: A complete radiographic examination should be taken four to six months after active orthodontic treatment. By this time the periodontal tissues should be returned to a normal condition and should no longer show the typical radiographic picture of active orthodontic treatment. Also, by this time, any traumatic occlusion will be registered.

2. Study models: Good impressions for accurate study models should also be made during the same visit. By this time the teeth will have settled into a

fairly stable functional occlusion. We all know the value of casts, and these should give us an approximate relationship of the teeth in centric occlusion and enable us to see how the teeth occlude from the lingual aspect. Lower lingual cusps often do not function in centric occlusion, but may make contacts in other excursions of the jaw; protrusive or lateral excursions.

3. Study of the patient's biting habits: The initial study of the patient's biting habits was, of course, made in the early orthodontic procedures, again during the stage of detailed positioning of the teeth with the orthodontic appliance, and now once again just prior to actual grinding. Particular note should be made as to whether the patient's incisive action is produced by a shearing force or by the contact of the incisive surfaces of the upper anterior teeth with the incisive surfaces of the lower teeth.

4. Plan of procedure: Having the complete picture before us by means of radiographs, study models, and a knowledge of the patient's biting habits, only then can we proceed intelligently with our occlusal grinding. Our diagnosis should be guided by a general history of the case, a further check into habits, and a consideration of the general health of the patient.

Having decided upon the amount of work to be accomplished, the initial selective spot grinding should be carried out first. By initial, I mean to adjust any cusps or deepen any fossa which would interfere with obtaining a good balance. Sometimes this initial grinding is necessary at the time of the placing of the retaining appliances, if a positioner were not used, or if, for some reason, the positioner did not completely correct such overloading.

In the grinding of the natural teeth, we consider each tooth as an individual unit; the occlusal contact of each tooth affects the opposite member, and the resultant occlusal force on each tooth is not transmitted to the supporting structure of the remaining teeth, but to the supporting structure of individual teeth.

The working side relations must be adjusted accurately in order that the individual tooth cusps and grinding inclines will maintain contact with their antagonists in all positions of mandibular movement to prevent the drifting of teeth.

I wish again to emphasize the fact that this is not mere spot grinding per se. We must follow a highly scientific procedure and, unless carefully planned, may cause irreparable harm. There are definite rules which guide the grinding of the teeth.

C. Procedure for Selective Spot Grinding.—The first important step is to determine the true centric position. This may be more difficult in orthodontic patients whose teeth have shallow sulci and grooves and rounded cusps. A sharpening of the cusps and deepening of the sulci and grooves may be advisable. Some cases, rather than close in true centric, will close to a certain contact and then slide forward slightly into protrusive or into a false centric relationship. A good rule to remember in correcting such a condition: grind mesial slope of upper cusps and distal of lower cusps.

1. Centric occlusion: When true centric has been established, we commence our procedure for grinding by examining for overloading in centric occlusion.

The auxiliary means employed in determining premature contact are: wax, articulating paper, palpation, patient response to question, visual examination, and sound on closure of teeth. Using cheek retractors, observe the closing of the jaws from rest position to centric occlusion and determine whether the sulcus should be deepened or the cusp in contact with it relieved, bearing in mind all the while the following points:

a. If the cusp of the lower tooth is in abnormal stress in centric occlusion, yet in harmony in the lateral excursions, deepen the sulcus of the upper tooth. Should the cusp of the lower tooth be relieved in this condition, the lateral relation might be disturbed.

b. If a cusp exhibits overloading in both centric occlusion and lateral excursion, it is advisable to grind that position of the cusp of the lower tooth that is in abnormal stress. Extreme care must be taken not to disocclude the tooth.

c. If there is premature contact in centric occlusion and no contact in lateral excursions (both working and balancing sides), the sulcus of the opposing tooth should be deepened. If the cusp of the lower tooth were to be ground, a wider separation would be created between the teeth of the opposing jaws in the lateral excursion.

When these corrections are properly executed, pressure is equalized over the entire dentition, and simultaneous stress is observed. Once centric occlusion is established, grinding of the teeth in other excursions should be accomplished in such a manner that the centric occlusion will not be disturbed. For example, when grinding on the working side one must grind from the point of centric contact (not including the point) along the planes which are interfering so as not to disrupt the already established centric occlusion. Frequently, by improper grinding, too many teeth are taken out of occlusion unnecessarily, thus complicating the grinding procedure.

The same rules apply to the grinding of any anterior teeth which may be striking too hard and require relief.

On rare occasions we may be forced to take a tooth out of contact in centric occlusion and depend on its contact in other excursions to prevent its extrusion.

2. Protrusive position: In this tip-to-tip position it is our desire to have as many teeth as possible contact simultaneously, thus distributing the load of occlusion over more teeth. At this time irregular incisive surfaces, due to malformation or chipped edges, are leveled off and made more esthetic. (Figs. 8, *B* and 9, *B*.) It is not imperative to have contact of the posterior teeth, as usually only the anterior teeth meet in this position, but again we repeat, the more teeth in contact the less will be the load on any individual tooth. Check for any interference of cusp-to-cusp contact in cases of simultaneous posterior contact.

It is best, if possible, to confine grinding in this position to the upper teeth. Grinding of lower teeth may cause nonocclusion in centric position. Common sense should tell us, however, that if we have an elongated lower anterior tooth it, not the opposing upper tooth, should be ground.

A.
B.
C.
D.

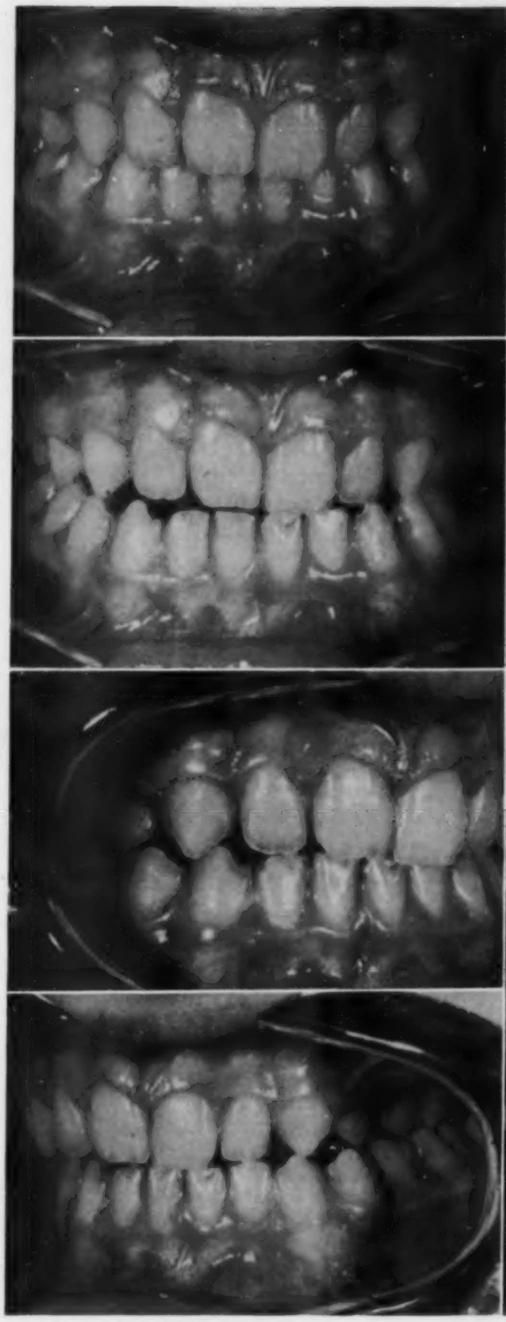

Fig. 8.

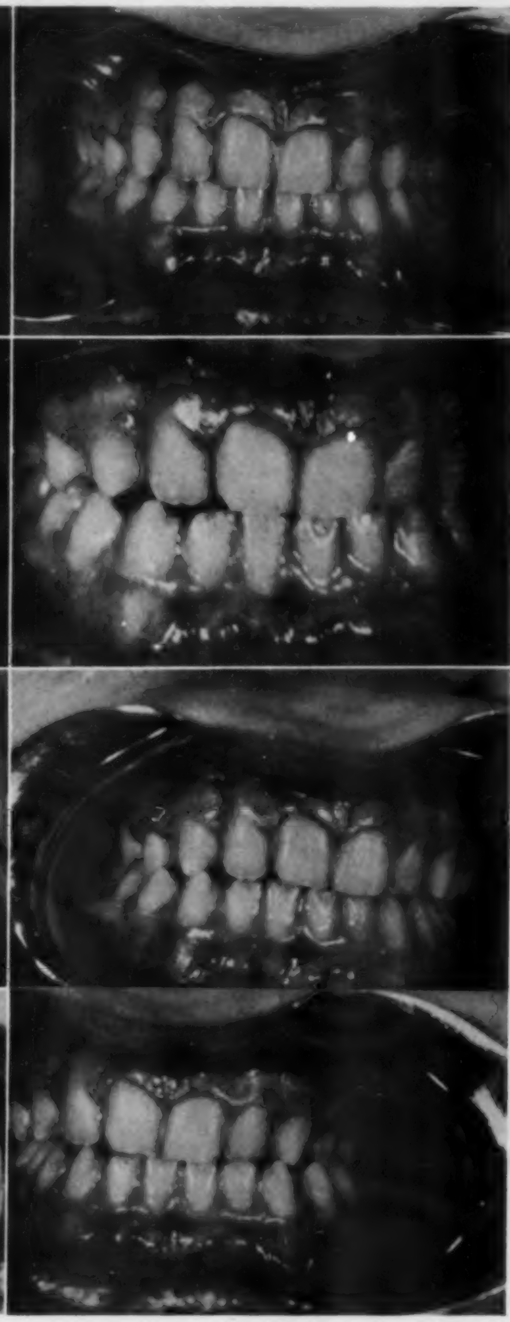

Fig. 9.

A.
B.
C.
D.

Fig. 8.—*A*, *B*, *C*, and *D*, Pregrind.
Fig. 9.—*A*, *B*, *C*, and *D*, Postgrind. (Same case as Fig. 8.)

3. Protrusive excursion: A correct protrusive excursion is obtained only when the lower jaw is moved straight forward with no lateral deviation. To check the patient for a correct protrusive excursion, note whether the median line of the lower jaw maintains the same relation with the median line of the upper jaw while the lower moves from centric to protrusive position. Use of a hand mirror by the patient facilitates the proper protrusion of the jaw.

In locating interfering cusps, it may be observed frequently that a patient deviates slightly to the side when moving the jaw forward. This deflection is not necessarily normal, although the patient may claim it to be both natural and comfortable. Mastication is generally subconscious, and the interfering tooth surface is bound to be struck and traumatized. It should, therefore, be relieved by proper grinding.

To verify the fact that cuspal interference produced the deviation in the forward thrust of the mandible, have the patient close in centric, then part the jaws slightly so that there will be no cuspal contacts as the jaw moves forward, and lastly have the patient make a protrusive excursion. If no deflection of the median lines occurs, cuspal interference, not habit, unequal pull of the muscles, nor pathosis of the temporomandibular joints is responsible.

When a patient experiences a protrusive excursion normally, there should be ease of motion from centric to protrusive with no interference. The lower anterior teeth should glide over the lingual surfaces of the upper teeth with ease.

Cusps of teeth interfering in this movement should be relieved, avoiding disturbance of centric occlusion whenever possible. Should the anterior teeth be displaced in their sockets during this movement, the angle of inclination should be changed. This may be accomplished by grinding the lingual surfaces of the upper anterior teeth from the point of centric contact to the incisal edge. Care must be taken not to grind the point of centric contact. These contacting surfaces should present inclinations that have essentially the same relationship as the cusp surfaces of the posterior teeth. (Fig. 10.)

4. Lateral excursions: In the lateral movements of the mandible it is most important that we secure simultaneous contact of as many teeth as possible on the working side. It is not so important to have contact on the balancing side in the natural dentition. However, if prematurities occur on the balancing side, relief must be made, otherwise periodontal disease or temporomandibular discomfort may follow. If balance can be secured without injuring the working side, there is every reason to seek it.

Mastication depends on two factors: cusp inclines and points of cusps functioning against these inclines. Often in improper corrective procedures, cusps are ground so that their sharpness is removed and not restored, resulting in discomfort and inability to masticate food properly.

During the lateral movement of the jaw, the lower buccal cusps on the working side glide along the lingual planes of the buccal cusps of the upper teeth; the buccal planes of the lower lingual cusps are likewise contacted by the lingual cusps of the upper. No tripping or displacement of teeth should be taking place. Buccolingual movement should be established without buccolingual strain.

With articulating paper as a guide, the patient is instructed to close the teeth in centric occlusion and then to glide the jaw laterally. Whether any displacement is taking place can be determined by placing the finger along the teeth on the working side.

Should the anterior teeth be in premature contact in this movement, they should be relieved by grinding the lingual surfaces of the upper anterior teeth from the point of centric contact (not including it) along the plane over which the lowers travel. If the lower teeth are ground, centric may be disturbed.

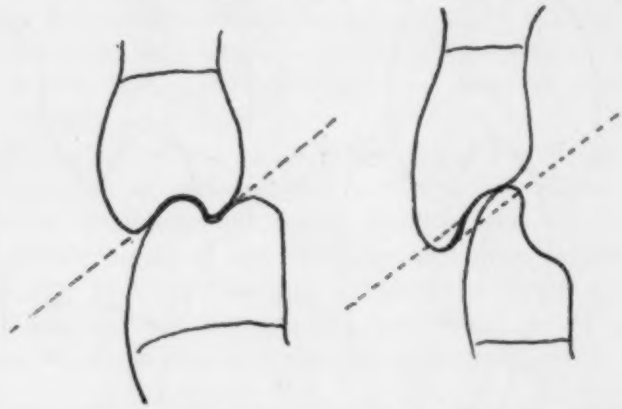

Fig. 10.—Diagram showing lateral view of cuspids and two posterior teeth on same side of arch. The cuspids would be in premature contact in the lateral relation as the lateral guiding inclines are not in harmony. The shaded portion of the upper cuspid should be removed. Contact of the cuspids is retained in the centric position, and harmony of guiding inclines and distribution of stress in the eccentric position are established. The removal of the dotted area of the lower cuspid would eliminate premature contact in the lateral position, but would take the cuspid out of contact in the centric and a portion of the eccentric relation, placing an undesirable burden on the posterior teeth. If the lower tooth were ground, either a closing of the bite or exfoliation might restore contact in the centric position, at which time the teeth would again be in premature contact in the eccentric position. (After Schuyler.)

The cuspids are often the chief causes of interference in lateral eccentric (Figs. 6, *C* and *D*, and 7, *C* and *D*). In such cases they should be ground from but not including the point of centric along both the mesial slope of the upper cuspids and the distal slope of the lower cuspids (Fig. 10). This condition can often be relieved or minimized during orthodontic treatment by soldering the bracket close to the occlusal edge of the band on the cuspids. In some patients with long, pointed cuspids, both soldering of brackets toward the occlusal edge of the cuspid bands and selective spot grinding will be necessary to overcome the cuspid interference in lateral excursions.

In the lateral excursive movements, the lower teeth should glide along the planes of the cuspid, premolar, and molar teeth with ease. The use of digital palpation and articulating paper should locate any premature contacts. The planes of the teeth are then ground from the point of centric contact along the buccal cusp inclines of the upper teeth and the lingual cusp inclines of the lower (Fig. 11). The surfaces of the teeth causing this undue pressure are relieved until they no longer interfere with the lateral movement. To grind the lingual cusps of the uppers or the buccal cusps of the lowers would interfere with centric occlusion because these cusps rest in the central fossae of the opposing teeth.

A word about the balancing side. Since the teeth in our orthodontic patients are generally strong and in good relation upon completion of orthodontic treatment, only a slight amount of grinding should need to be done to procure contact on the balancing side. If more than this is required, leave well enough alone as balancing side contact is not necessary for stability; it is often undesirable.

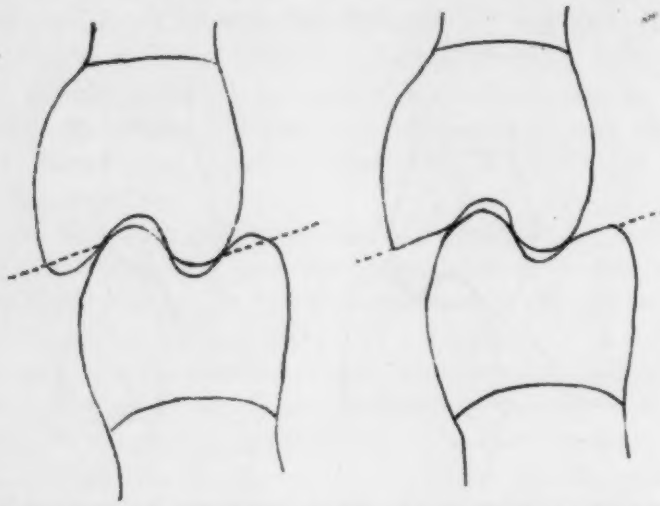

Fig. 11.—Diagram showing suggested areas for selective spot grinding in upper and lower posterior teeth to reduce horizontal stress in lateral eccentric positions. The untouched upper lingual and lower buccal cusps maintain the maxillomandibular opening.

A serious problem exists if more pressure is felt on the balancing side than on the working side, for it means that the upper lingual cusps are exerting overstress on the buccoclusal inclines of the lower posterior teeth. This condition is found in those orthodontically treated cases in which overexpansion resulted in the upper posterior segment causing the crowns to flare bucally. The balancing inclined planes must be in harmony with the working planes on the opposing side. When premature contact exists on the balancing side, it is because the guiding inclines are too steep as related to the working inclines on the opposite side. Correction is made by reducing the steepness of the guiding inclines not by grinding the upper lingual cusps. Frequently the contact is in the region of the distobuccal groove of the lower molar, so by widening this groove the excess stress can often be relieved without causing an upset in the centric occlusion. Excessive balancing side contacts often leads to painful sequelae and temporomandibular disturbances.

The ideal equilibration in the lateral movements of the jaw should, when completed, give an even contact on the working and balancing sides, although, as previously stated, balancing side contact is not essential. Free, uninterfered movement should be our goal.

Finally, a recheck should be made of centric occlusion for the simultaneous contact of all the teeth.

Milling-in by use of abrasive pastes is definitely contraindicated. Any roughness should be cared for by polishing wheels. Abrasive pastes will wear

down all occlusal contacts, not merely offending areas, and thus centric will be lowered with nothing gained.

Common sense and good judgment should always be our guide as to the amount of grinding. It is not advisable to attempt to complete all necessary grindings in one sitting. Minimal amounts should be done over a considerable space of time. During the retention period, when visits are spaced one every two or three months, each time a patient presents the occlusion should be checked for equilibration.

Grinding does not usually make the teeth sensitive, if carefully done, but in some cases sensitiveness may occur. At worst it lasts only for a short period, disappearing in a few days. Should it continue, however, formalin may be rubbed into the sensitive area.

There is little danger of the exposed dentine being susceptible to caries because all grindings are on self-cleansing surfaces.

It is my opinion that much of the buckling of the lower anterior teeth that takes place after removal of the retaining appliances can be overcome, or minimized, by careful and selective spot grinding as outlined in this thesis. Discrepancy in tooth material between the upper and lower anterior teeth, however, will have its effects even in properly positioned teeth and equilibrized occlusions.

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VARIATIONS IN FACIAL RELATIONSHIPS: THEIR SIGNIFICANCE IN TREATMENT AND PROGNOSIS

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I. INTRODUCTION

"THE line with which in form and position according to type the teeth must be in harmony if in normal occlusion." This sentence which Angle[1] used to define the "Line of Occlusion" could well bid for the distinction of being the most important sentence in orthodontic literature. It implies harmony and balance of the denture, an ideal which orthodontists strive to accomplish. In his explanation of the "Line of Occlusion," Dr. Angle said:

> That as the dental apparatus is only a part of the great structure—the human body—each part and organ of which was fashioned according to lines of design, it must have been intended that the line of occlusion should be in harmony in form and position with, and in proper relation to, all other parts of the great structure, according to the inherited type of the individual.

It is quite clear that Angle thought of the denture as an integral and correlated part of the body structure. He recognized variations in form and in inherited characteristics of type, and he believed that the teeth must be in harmony and balance with each other and with their associated structures.

He also gave much thought to the conformation of the face and devoted an entire chapter of his book to it under the title "Facial Art." Here one may read these words:

> . . . we should be able to detect not whether the lines of the face conform to some certain standard, but whether the features of each individual—that is, the forehead, the nose, the chin, the lips, etc.—balance, harmonize or whether they are out of balance, out of harmony, and what concerns us most as orthodontists: whether the mouth is in harmonious relations with the other features, and if not what is necessary to establish its proper balance. Now, the ability to determine the proper balance of the features is rare. One of our foremost teachers, Mr. E. H. Wuerpel, says that only one in two or three hundred of even art students ever succeed in mastering it, and these only after much observation and practice in sketching and modeling the human face.

Dr. Angle believed that he had an answer to the creation of harmonious relations of facial features for he said:

> It is, furthermore, a law so plain and so simple that all can understand and apply it. It is that the best balance, the best harmony, the best proportions of the mouth in its relations to the other features requires that there shall be the full complement of teeth, and that each tooth shall be made to occupy its normal position—normal occlusion.

From the Department of Orthodontia, College of Dentistry, University of Illinois.
Presented at the Forty-fourth Annual Meeting of the American Association of Orthodontists, Columbus, Ohio, April 26-29, 1948.

The previous quotations, together with much of Angle's other writing, reflect a belief that each individual has an endowed or inherited potential for perfection and that although each may vary from every other, such variation is harmonious. Following this line of reasoning, all malocclusion would be acquired, that is, the result of environmental factors, and correction should be possible with the end result of normal occlusion, that is, a full complement of teeth correctly related to each other.

For many years the followers of Angle's teachings adhered to this philosophy. Probably no other concept in orthodontic treatment has been better tested. No one argues that a full complement of teeth is not important or desirable, but many have believed that functional and esthetic harmony of the denture and face is more important. One of these was Cryer,[2] Professor of Oral Surgery at the University of Pennsylvania, who wrote in 1904:

> During the past three years many papers have been published on the subject of irregularities of the teeth and their treatment, and while some of them are of unquestionable value, covering points of capital importance in the field of orthodontia, the author feels, however, that due consideration has not always been given to the outlines of the face which are molded upon the topographical anatomy of the facial bones, the alveolar processes, and the teeth.
>
> In the correction of irregularities of the teeth and their processes, three fundamental principles should always be considered. First, the operator should carefully regard the outlines of the face, especially as they should appear in early adult life; the difference in treatment demanded by the male and female type should be observed; the variations in each individual should be considered, and each case treated according to its own requirements. Second, due consideration should be given to the appearance of the teeth when the lips are open, as in talking and laughing. Third, the importance of occlusion in regard to vocalization, appearance and mastication.
>
> Many writers, especially of late, claim that irregularities of the teeth, should always be corrected without the extraction of one or more teeth, as "Nature never puts teeth into a mouth that do not belong to that physiognomy!" Your writer thinks this is doing Nature a great injustice; many teeth are found within the mouth which should be removed, not only for the correction of irregularities but for the general comfort and health of the patient.

Case,[3] who was also contemporary with the development of orthodontia as a specialty, likewise believed that functional and esthetic harmony of the denture and the face was the most important objective to be sought and that a full complement of teeth was desirable when compatible with facial balance and harmony. He advocated extraction of dental units in some cases in order to obtain what he believed to be the "Best Dento-Facial Harmony."

For many years it has been the practice of those who did not adhere to the Angle teachings to sacrifice dental units in those cases where they believed a disharmony existed between these organs and the bones of the jaws. Grieve[4] is one of those accepting the latter philosophy, and he has written extensively on the subject. This philosophy has recently been reintroduced by Tweed,[5] who

found that he could not obtain esthetically balanced and stable dentures in many of his cases by any other method of treatment. He built his philosophy of analysis and treatment around the relationship of the lower incisors to their supporting basal bone.

This controversy has led to an intensive search for significant dentofacial relationships by both the clinician and the research worker. Numerous publications have reflected this activity. Lundquist[6] studied the relationships of the apical base to the dental arch. Hellman[7] measuring skulls reported on such a study in 1929. He made this statement about facial pattern:

> It may thus be emphasized that while normal development of the face and teeth may bring about differences, they are distinguishable as facial types. Such types may be observed in different races and also among different individuals of the same race. When differences in development become abnormal they represent the same aspect in all racial groups and are distinguishable as malocclusion type.

Broadbent,[8] using the cephalometric method, has presented a mean facial pattern. Brodie,[9] using a similar method, has given us the growth pattern from birth to the eighth year.

Tweed,[10] Salzmann,[11] and others have presented findings of their study of the mandibular plane angle.

Unfortunately, it would be impractical to list all of the work that has been presented.* It represents the contemporary history of the development of our knowledge on the subject of dentofacial relationships.

The present paper presents the findings of a study which has been pursued by the author for the past five years. It was undertaken to determine the range of the facial and dental pattern within which one might expect to find the normal, and further to discover whether any usable correlations existed in such normals.

II. METHOD AND MATERIAL

The method employed in the study was roentgenographic cephalometry, and the technique was that described in various papers familiar to all orthodontists.

The control material studied was derived from twenty living individuals, ranging in age from 12 to 17 years and about equally divided as to sex. Models, photographs, and cephalometric and intraoral roentgenograms were taken of each. All individuals possessed clinically excellent occlusions.

Tracings were made of all lateral head x-rays taken with the teeth in occlusion and the Bolton triangle outlined on each tracing according to Broadbent's[8] technique, which consists of connecting the following points (Fig. 1): Nasion to the center of sella turcica and sella to the Bolton point, which is the superior point on the concavity behind the occipital condyles. Continuing from the Bolton point back to nasion completes the Bolton triangle, which represents the area at the base of the cranium to which the face is joined. It is believed by Broadbent[8] to be the most stable area from which to make serial comparisons. This area itself must, of course, increase as the head grows, so Broadbent has located a point within the triangle by taking the mid-point of a perpendicular

*A rather extensive bibliography can be found following Chapter 13 in Salzmann's *Principles of Orthodontics.*

from the Bolton plane to the center of sella turcica. He calls this the registration point. When serial tracings are studied, they may be registered on this point with their Bolton planes parallel. The other landmarks and planes used in this study are given in the glossary and shown in Fig. 1.

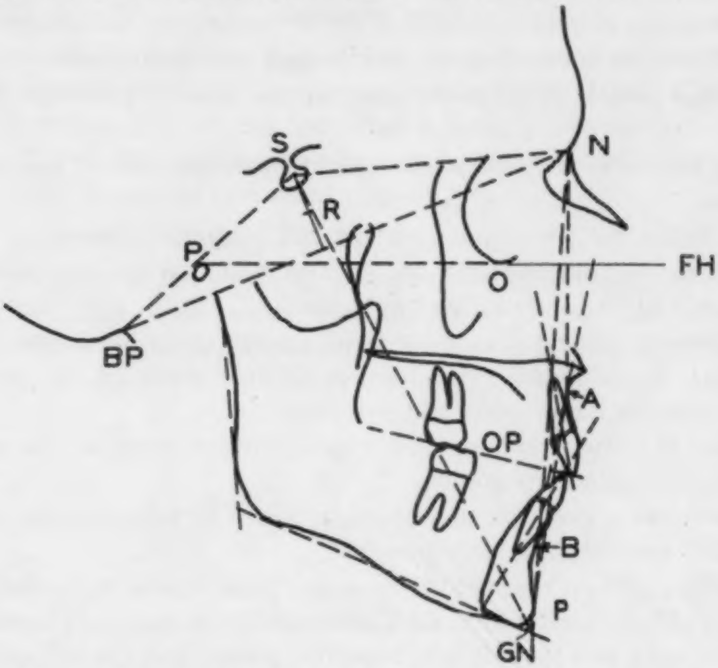


Fig. 1.—The points and planes used in the study (see glossary).

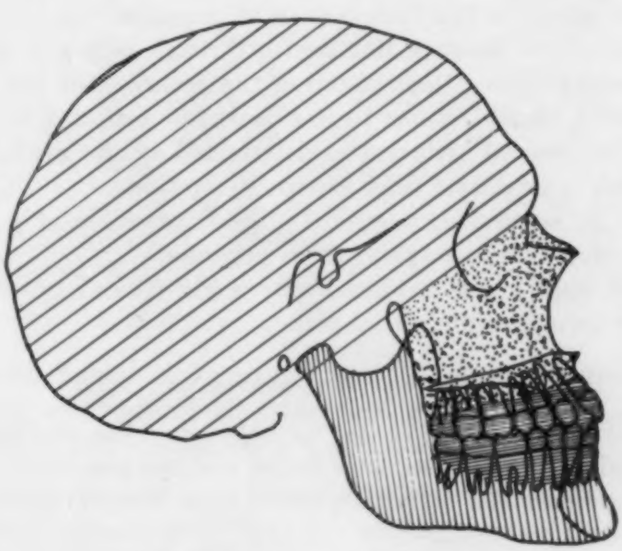


Fig. 2.—The areas of the head.

For the purposes of this study the head was divided into cranium and face (Fig. 2). The face was further divided into: (1) upper face, (2) teeth and alveolar area, and (3) lower face or mandible.

As the investigation progressed, two objectives developed: to appraise (1) the pattern of the facial skeleton exclusive of the teeth and alveolar process and (2) the relationship of the teeth and alveolar process to the facial skeleton.

III. GLOSSARY

1. *Nasion:* the suture between the frontal and nasal bones.
2. *Bolton point:* the highest point on the concavity behind the occipital condyles.
3. *The center of sella turcica:* located by inspection of the profile image of the fossa.
4. *Orbitale:* the lowest point on the left infraorbital margin.
5. *Porion:* (cephalometric)* the highest point on the superior surface of the soft tissue of the external auditory meati.
6. *Pogonion:* the most anterior point on the mandible in the midline.
7. *Point A—subspinale:* the deepest midline point on the premaxilla between the anterior nasal spine and prosthion.
8. *Point B—supramentale:* the deepest midline point on the mandible between infradentale and pogonion.
9. *Gnathion:* a point on the chin determined by bisecting the angle formed by the facial and mandibular planes.
10. *Bolton plane:* represented by a line from nasion to Bolton point.
11. Frankfort horizontal: (cephalometric)* a horizontal plane running through the right and the left cephalometric porion and the left orbitale.
12. *Mandibular plane:* a line at the lower border of the mandible tangent to the gonion angle and the profile image of the symphysis.
13. *Facial plane:* a line from nasion to pogonion.
14. *Denture base limit:* a line drawn through points A and B.
15. *Occlusal plane:* a line bisecting the occlusion of the first molars and central incisors. Should either incisor lack full eruption or be in supra- or infraclusion, the general occlusion as determined by the premolars is used.
16. *Y axis:* a line from sella turcica to gnathion.
17. *Angle of convexity:* formed by the intersection of a line from nasion to point A with a line from point A to pogonion.
18. *Facial angle:* the inside inferior angle formed by the intersection of the Frankfort horizontal and facial plane.

IV. OBSERVATIONS

1. The Skeletal Pattern in Norma-Lateralis.—The skeletal pattern of the face is determined by the maxillary bones and the mandible. While the teeth and alveolar process also influence facial form, they will be considered separately as the denture.

The skeletal pattern can be laid out on lateral cephalometric x-rays as a polygon and its form or pattern described by the angular relationships of vari-

*True or anthropometric porion and Frankfort plane are located on the superior bony surface of the external auditory meati.

ous planes (Fig. 3). Those to be described in this study are the facial angle, angle of convexity, the anteroposterior relationship of the denture bases, mandibular plane angle, and the Y axis.

It is customary for orthodontists to classify facial types according to the degree of recession or protrusion of the mandible. As this attribute of facial form is determined by a skeletal foundation, it would obviously be an advantage to classify skeletal pattern in a manner consistent with facial type as this is appraised by examination of the individuals or their photographs. So far it has been found that this can best be accomplished by relating certain planes of the pattern to the Frankfort horizontal plane.

Facial Angle (Fig. 4).—This angle is an expression of the degree of recession or protrusion of the chin. It is determined by drawing a line from nasion to pogonion, this plane being called the facial plane. The inferior inside angle of its intersection with the Frankfort horizontal is designated as the facial angle.

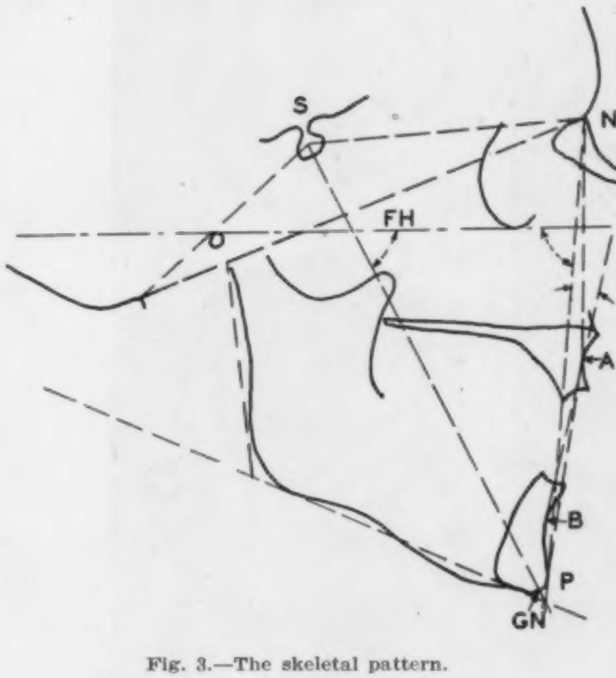


Fig. 3.—The skeletal pattern.

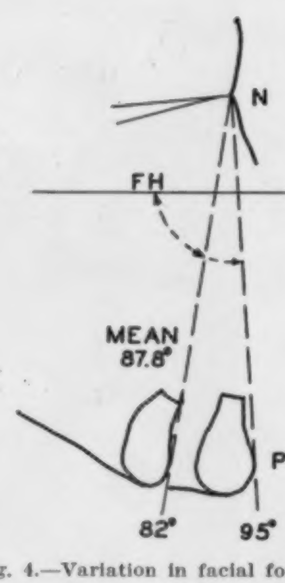


Fig. 4.—Variation in facial form.

The mean value for the series was 87.8°. The range was from 82°, representing a recessive chin approaching the facial type usually associated with Class II malocclusion, to 95°, indicating a protrusive chin.

The Frankfort Horizontal as a Plane of Orientation.—To test the validity of the Frankfort plane as a substitute for strictly cranial planes in the appraisal of the lateral profile x-rays, the following method was employed. All of the cases in the study were arranged in an order of increasing magnitude of the facial angle (see Column A, Table I). The same order of cases was maintained and the measurement of the angle formed by the intersection of the facial

plane to the line S – N was tabulated in Column B. Following the same order of cases, the angle formed by the facial plane to the Bolton plane was tabulated in Column C.

TABLE I

	A FACIAL ANGLE		B FACIAL PLANE TO S-N		C FACIAL PLANE TO BOLTON PLANE	
		1 t		2 t		14 t
	*82	2	75.5	8	70.5	20
	83	3	79.5	3	‡75	11
	84	4	76	14	69.5	18
	85	5	82	9	72.5	19
	85	6	80	11	73	8
	85	7	81.5	7	68.5	9
	85.5	8	79	1	68.5	12
	86.5	9	*74	6	70	2
	86.5	10	79	20	63.5	3
	86.5	11	‡86.5	4	65.5	5
	†87	12	78	5	67	16
	88.5	13	78.5	15	70.5	17
	88	14	82	18	71	1
	90	15	83.5	17	*63	10
	90	16	82.5	12	†69	13
	90.5	17	81.5	10	70	7
	92.5	18	†80	16	68	15
	93	19	82.5	13	70	6
	93.5	20	81.5	19	67.5	4
	‡95		85		66	
Mean	87.8		80		69	
Range	82 to 95		74 to 86.5		63 to 75	

[t]sequence.
*minimum angle.
†mean angle.
‡maximum angle.

When it is recalled that all of the cases presented excellent dentitions, it is seen that these may range from 82° to 95° (13.0°) with a mean of 87.8° when appraised according to the facial plane to Frankfort plane. The same cases appraised by referring the facial plane to S – N reveal a range of 74° to 86.5° (12.5°) with a mean of 80°, while the facial plane to the Bolton plane yields a range of 63° to 75° (12°) with a mean of 69°. Thus the range exhibited by the three angles is almost identical and the question naturally arises as to why the facial angle is more desirable than the other two.

When the relative position of the mean, minimum, and maximum angles of the three methods is compared, a distinct lack of correlation is noted. A comparison of the photographs of these individuals showed the facial angle to be far superior in classifying facial type. This fact is even better illustrated in Fig. 5, the profile photographs of four individuals with widely different types of faces. *A* has a recessive or Class II type face; *B*, a Class I type or average face; *C* has a slightly more protrusive lower face but one which is still within Class I limits; *D* shows an excessive mandibular protrusion or the Class III type face.

A. *B.*

C. *D.*

Fig. 5.—The facial angle.

In Table II these four faces are appraised by the three methods shown in Table I, i.e.: (1) facial angle; (2) facial plane to S – N; (3) facial plane to Bolton plane. Column A gives the facial angle and its relationship to the mean and the range of the control series.

Reference to Column B of the same table reveals the result of classifying the same cases according to the relation of the facial plane to the line S – N.

Case *A* now becomes a Class I type, tending toward protrusiveness; *B*, a Class I type—less protrusive than A; *C* becomes a Class III type, *D*, a Class III of still greater degree.

Column C of Table II reveals the result of classifying these cases according to the relation of the facial plane to the Bolton plane. Now *A* becomes an excessive Class II as does also *B; C* and *D* both fell at the exact mean denoting an average or Class I face.

TABLE II

CONTROL SERIES CASE NUMBER	A FACIAL ANGLE 82 TO 95 MEAN, 87.8	B FACIAL PLANE TO S - N 74 TO 86.5 MEAN, 80	C FACIAL PLANE TO BOLTON PLANE 63 TO 75 MEAN, 69
A	82	82	58
B	88.5	81	64
C	90	87	69
D	96	89	69

This is not to be construed as a criticism of the S – N and Bolton planes as planes of reference in certain studies. Our own results would indicate an almost identical degree of stability in the three. It should be recalled, however, that both S – N and Bolton constitute dividing lines between face and cranium and therefore are measures of craniofacial relations. The Frankfort plane, on the other hand, cuts across the face and hence would be a more logical choice for a study of relationships involving only the face. It is in these relationships that the interest of the orthodontist lies. In an examination of a large number of individuals, I have yet to find a facial angle that was not a good expression of the facial type of the individual as appraised by his profile photograph.

All that has been said thus far relates to the degree of recession or protrusion of the lower jaw, but this is only one factor in the appraisal of skeletal pattern. Four others have been used: Angle of convexity, A-B plane, mandibular plane, and Y axis.

Angle of Convexity (Fig. 6).—This is a measure of the protrusion of the maxillary part of the face to the total profile. The angle is formed by two lines, one from nasion and the other from pogonion, both meeting at *A*. The mean of the control group was a straight line or 180°. In such a case the angle of convexity would, of course, coincide with the facial plane and be *0*. If the point *A* fell posterior to the facial plane, the angle formed was read in minus degrees, and if anterior, in plus degrees. The range in the controls was found to be + 10° (convex) to –8.5° (concave).

A-B Plane (Fig. 7).—The location of this plane in relation to the facial plane is a measure of the relation of the anterior limit of the denture bases to each other and to the profile. It permits estimation of the difficulty the operator will meet in gaining correct incisal relationships and satisfactory axial inclinations of these teeth. In the control group the relation of this plane to the facial plane was found to range from parallelism or 0° to a posterior position of B which could be read as –9°. The mean was –4.8.

The Mandibular Plane Angle (Fig. 8).—This is a measure of the relationship between the Frankfort plane and a tangent to the lower border of the mandible, recently brought into prominence by Tweed[10] and Salzmann[11] as a clinical diagnostic aid. In our controls of excellent dentitions, the angle formed by these two planes ranged from 28° to 17°. The mean was 21.9°.

The coefficient of correlation between the mandibular plane angle and the facial angle was found to be -0.726 which is an indication that as the facial angle decreases (chin more posterior) the mandibular plane angle tends to increase (mandibular border becomes steeper).

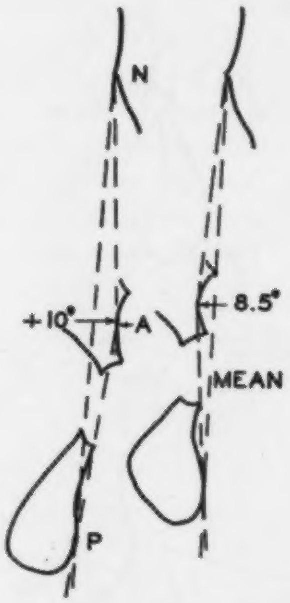


Fig. 6.—The angle of convexity.

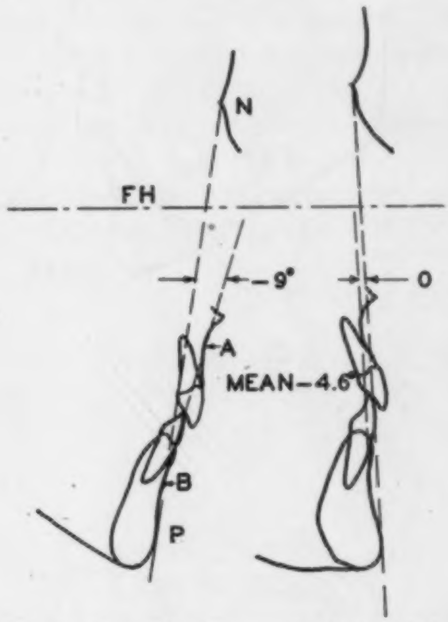


Fig. 7.—The A-B plane to the facial plane.

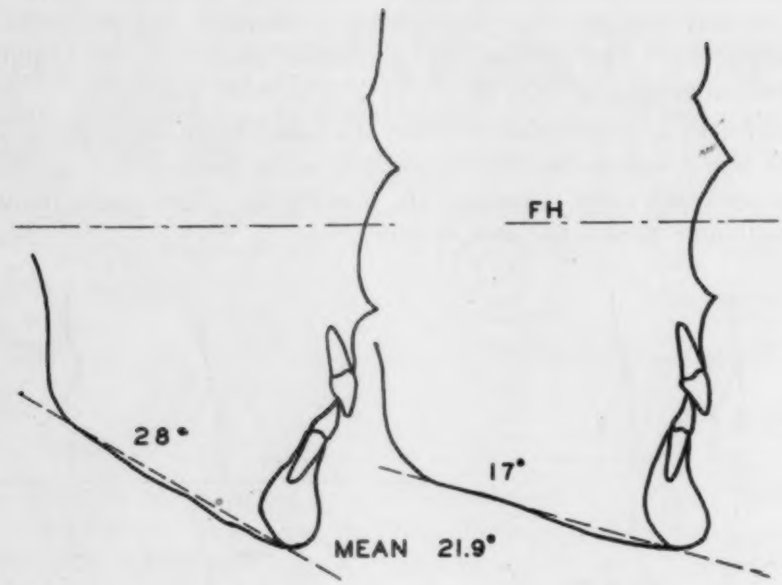
Y Axis (Fig. 9).—As the face swings out from under the cranium in its growth and development from birth to maturity, it said to grow in a downward and forward direction. A line from sella turcica to gnathion has been used as an expression of the direction of this growth and called the Y axis.

TABLE III

	MINIMAL	MAXIMAL	MEAN	STANDARD DEVIATION
Facial angle	82	95	87.8	3.57
Angle convexity	-8.5	+10	0	5.09
A-B plane to facial plane	- 9	0	-4.6	3.67
Mandibular plane angle	17	28	21.9	3.24
Y axis to Frankfort plane	53	66	59.4	3.82

The angular relationship between the Y axis and the Frankfort plane of the control group yielded a mean of 59.4° with a range of 66° to 53°. To recapitulate on skeletal pattern, Table III gives the range and means of the angles used in the analysis.

Fig. 8.



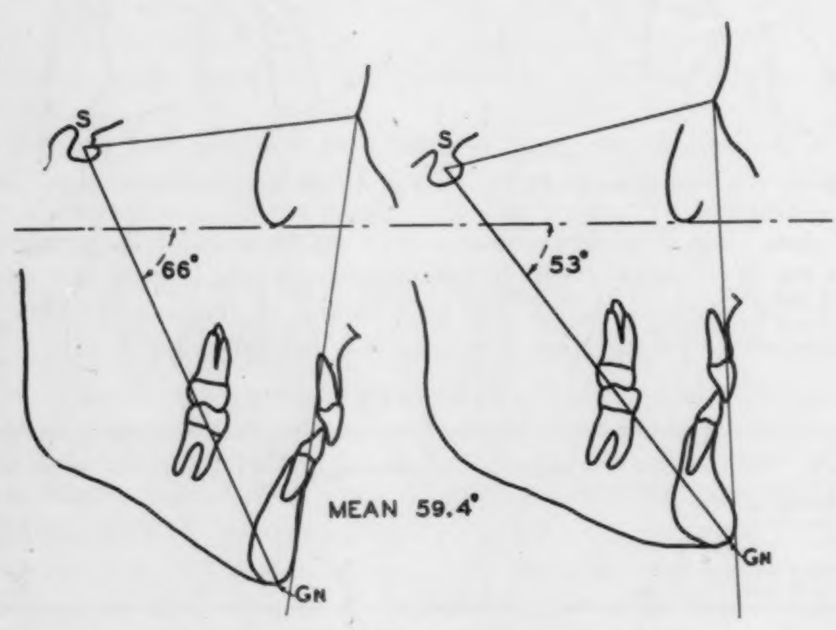


Fig. 9.

Fig. 8.—The mandibular plane angle.
Fig. 9.—The Y axis angle.

Within these ranges one can expect to treat a malocclusion to a well-balanced face provided one maintains a balanced relationship of the denture to the skeletal pattern. Excessive deviations of any of these relationships may be considered as unfavorable variations which reduce the prospects of obtaining a harmoniously balanced face, in direct ratio to the amount of deviation.

Two similar investigations are available for comparison with three of the angles reported in this study. Mayne[12] studied fifty cases designated as clinically normal occlusions. The age range was 18 to 35 years. He used an angle formed by a plane from nasion to gnathion with the Frankfort plane. This differs from the facial angle used in this series in that gnathion is slightly posterior to pogonion. A test of ten cases showed that this made an average difference of −1.25° in readings; therefore this amount has been added to Mayne's findings to make them comparable to the facial angle. The other angles compared; mandibular plane angle and cant of occlusal plane were recorded as in this study.

Bushra[13] studied forty cases, twenty of them being the same cases used in my series. In addition, he used twenty adult cases, and it is these latter cases that are shown in Table IV.

TABLE IV

	FACIAL ANGLE		MANDIBULAR PLANE ANGLE		CANT OF OCCLUSAL PLANE	
	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE
Downs 20 cases 12-18 yr.	87.8	82 - 95	21.9	28 - 17	+9.5	+14 - +1.5
Mayne 50 cases 18-36 yr.	88	79.5 - 95.5	22.9	40.5 - 9	+7.4	+25 - −1
Bushra 20 cases 18-67 yr.	88.7	81.5 - 95	23.5	39 - 16	8.2	+13 - +2

The similarity of the finding of the facial angle is striking. The mean findings of the other angles are very close. The ranges, however, are greater than those in this study. This can be accounted for in two ways: First, in limited sampling of material of this nature, the minimum and maximum extremes can be expected to vary when additional material is studied; second, they may have been less critical in selecting material.

2. *Relationship of the Denture to Skeletal Pattern.*—The second area of the face to be investigated was that comprising the teeth and alveolar process. This region has particular significance to the orthodontist because it contains the tissues which respond directly to orthodontic therapy.

The relationships (Fig. 10) which at the moment appear to be of the greatest clinical importance are: (1) the cant of the occlusal plane; (2) the axial inclination of the upper and lower incisors to each other; (3) the axial inclination of the lower incisors to the mandibular plane; (4) the axial inclination of the lower incisors to the occlusal plane; (5) the amount of protrusion of maxillary incisors. These relations are obtained by the following methods.

Cant of Occlusal Plane (Fig. 11).—In order to make angular readings, the occlusal plane was represented as a straight line. It was laid out by bisecting the first molar cusp height and incisal overbite and connecting the two with a

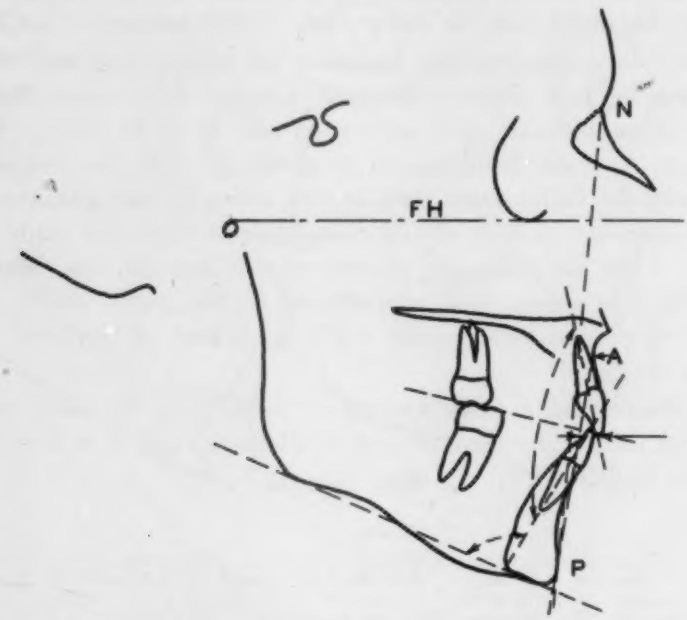


Fig. 10.—The denture to the skeletal pattern.

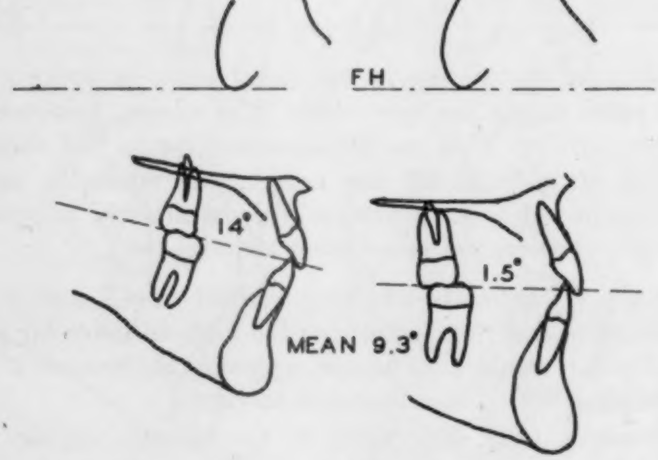


Fig. 11.—The cant of the occlusal plane.

straight line. (In the appraisal of severe malocclusions, where the incisors are obviously in extreme positions of supra or infra occlusions, these teeth may be disregarded and molars and premolars used.)

The angular relation between the occlusal plane and the Frankfort plane in the control series ranged from +14° to 1.5° with a mean of +9.3°. A coefficient of correlation of -0.775 between this plane and the facial angle indicated that there was a tendency for the planes to approach parallelism as the facial angle increased. Generally speaking, the Class II facial types have a relatively steep occlusal plane. As the facial type approaches the Class III pattern, the occlusal plane tends to become more horizontal. (Should the relationship exceed parallelism through a drop of the posterior end of the occlusal plane, the readings are made in minus degrees.)

Axial Inclination of Upper and Lower Incisors (Fig. 12).—This is a measure of the degree of procumbency of the incisor teeth. In order to read the relation of the upper to the lower teeth, lines are drawn representing their axis. A tabulation of the inside angles of this relationship in the control cases yielded a mean of 135.4° with a range from 130° to 150.5°.

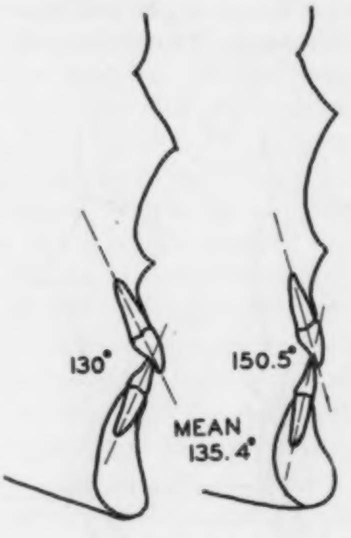


Fig. 12.

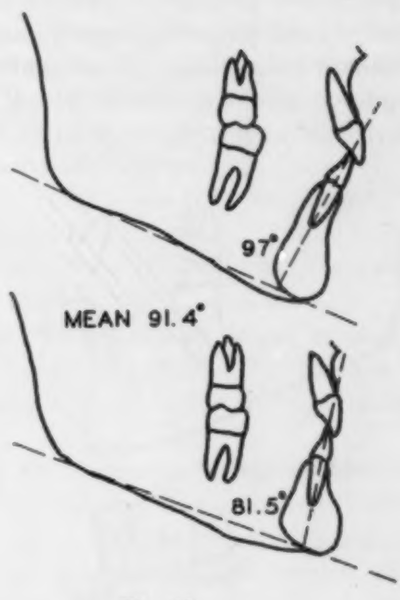


Fig. 13.

Fig. 12.—The axial inclination of upper to lower incisors.
Fig. 13.—The incisor-mandibular plane angle.

Axial Inclination of Mandibular Incisor to Mandibular Plane (Fig. 13).—A number of studies have been reported on this relationship (Margolis,[14] Noyes, Rushing, and Sims,[15] and Speidel[16]) with a general agreement on ranges and on a mean of 90°. Our control group yielded a mean of 91.4°. The difference in the mean can be accounted for by the slightly different method of locating the mandibular plane. All previous studies have located the mandibular plane tangent to the lower border of the mandible at gonion and the lowest anterior point which usually is found beneath the premolars. As the latter point is not in the midline and serial observations indicate oppositional growth in this area causing an increasing bulge, the lowest point of mandible in the midsagittal

plane (menton) is used as the anterior tangent point for determining the mandibular plane.

As the average relationship of the lower incisors to the mandibular plane is approximately a right angle (90°), it appears to be more descriptive to denote the inclination of these teeth in degrees of deviation from a right angle relationship to the mandibular plane; thus a labial tip of the incisors is described as plus the number of degrees in excess of 90°, and a lingual tip as minus the number of degrees less than 90°. The range in our control series is +7° to −8.5° with a mean of +1.4°.

Axial Inclination of Lower Incisors to the Occlusal Plane (Fig. 14).—To test further the tip of the lower incisors to their axis may be compared with the occlusal plane. This seems to be a logical method, for the incisors are then being related to their functioning surface, the occlusal plane. Further, it has been observed that the mandibular plane angle has a wide range when dealing with extremes of skeletal patterns. The axial inclination of the lower incisor to the occlusal plane has been found to be helpful in checking and interpreting the incisor-mandibular plane angle. The inferior inside angle was read and the plus or minus deviation from a right angle recorded. The range was from +3.5 to +20 with a mean of +14.5.

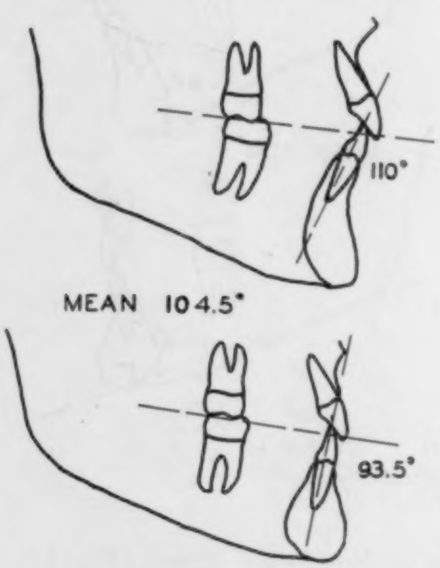


Fig. 14.

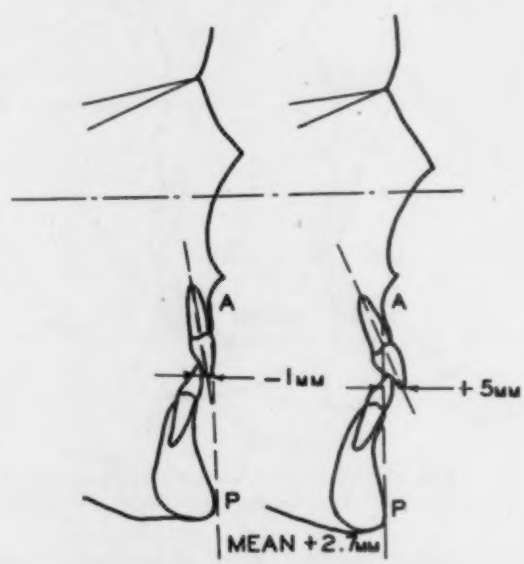


Fig. 15.

Fig. 14.—The lower incisor to the occlusal plane. These angles are recorded as the degrees of their deviation from a right angle, thus 97° is a +7°; 81.5° is a −8.5°; and 110°, a +20, and 93.5°, a +3.5°.

Fig. 15.—The distance of the upper incisor to the A-P plane.

Protrusion of Maxillary Incisors (Fig. 15).—The distance of the incisal edge of the maxillary central incisor to the line *A-P* is a measure of maxillary dental protrusion and is read in millimeters. In the control group it was found to vary from +5 mm. (anterior) to −1 mm. (posterior) to the A-P line with a mean of 2.7 mm.

The relationship of the denture to the skeletal pattern lends itself to a formula of means and extremes similar to the one on skeletal pattern and is shown in Table V.

TABLE V

	MINIMAL	MAXIMAL	MEAN	STANDARD DEVIATION
Cant of occlusal plane	+1.5	+14	+ 9.3	3.83
$\underline{1\|}$ to $\overline{\|1}$	130	150.5	135.4	5.76
$\overline{\|1}$ to mandibular plane	–8.5	+ 7	91.4	3.78
$\overline{\|1}$ to occlusal plane	+3.5	+20	+14.5	3.48
Distance $\underline{\|1}$ to facial convexity plane A-P	– 1 mm.	+ 5 mm.	+ 2.7	3.05

V. DISCUSSION

One studying cephalometric roentgenograms soon becomes conscious that they show considerable difference in general pattern. Lateral views in particular show a wide variation in the relationship of the component parts of the face. These differences are observed in the way the face is related to the cranium, in the general contour of the profile, and in the relationships of the teeth to the skeletal pattern. There develops a sense of balance and harmony in the x-rays of those individuals who possess excellent untreated occlusions. They represent standards against which malocclusions and treated cases may be judged. Fig. 16 shows the profile outlines of the cases used in this study. While differing in pattern, they show a similarity in balance. Note in particular the relationship of the incisor teeth to facial plane.

Tables III and V, giving the variations of skeletal and dental relationship, permit the expression of a facial pattern by means of figures. Figures also have the advantage of accurately expressing changes which occur during treatment, as the result of growth, or both.

Exceptions, of course, will be found to the means and extremes derived in this study for the sample is small. Facial types are also known to differ racially, and this study is limited to the white race. This, however, does not negate the use of the method and tables, as in the last analysis the total picture of denture and facial balance and harmony can only be ascertained after evaluation of: (1) skeletal pattern and the relationship of denture to it; (2) occlusion and function of the teeth; (3) function of the facial musculature.

Patients seek orthodontic treatment because a malocclusion is present. They may have esthetically harmonious and functionally balanced facial musculature, or they may present varying degrees of disharmony and imbalance. If the former condition is present, the headplate analysis will give readings either within the normal range or with only slight deviations. As these cases do present good muscle balance, it would be desirable not to destroy this by placing teeth in unfavorable relationship to the skeletal pattern. In those cases with poor functional and esthetic balance, the fault will lie in a poor skeletal pattern or in a faulty relationship of the denture to the skeletal pattern, or both conditions may be present. The cephalometric readings will locate and give the amount of disproportion.

Skeletal patterns are relationships over which we have very little control in orthodontic treatment except by the use of surgical techniques. We must not forget, however, that in most of our cases maturation is going on and that there are variations between individuals in the downward and forward direction of growth of the face. In other words, there are three possibilities to consider: (1) horizontal and vertical growth may be equal, in which case the direction of growth (Y axis) will not change; (2) horizontal growth will exceed vertical growth and the Y axis angle will decrease, indicating a forward swing of the face; (3) the other alternative would be where vertical growth exceeds horizontal growth and the Y axis angle increases. The manner in which the face grows during and after treatment has a significant bearing on the prognosis of a case.

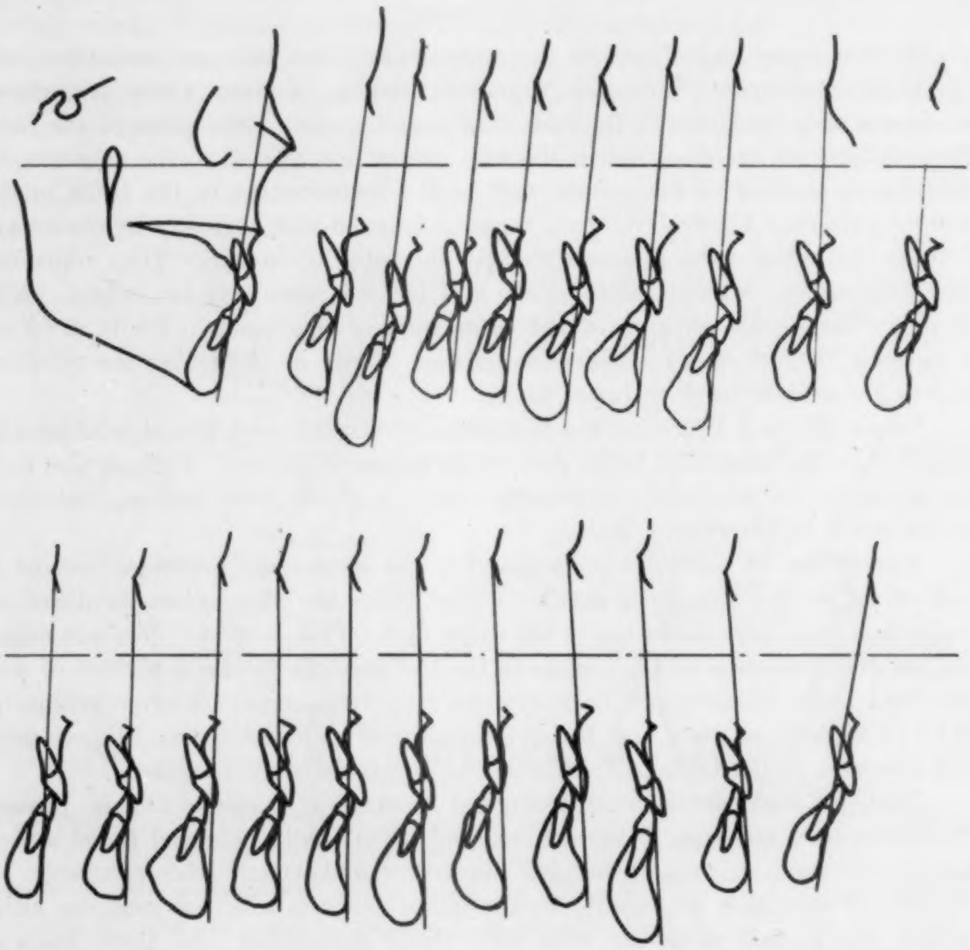


Fig. 16.—A composite of the cases studied arranged in the order of the increasing magnitude of the facial angle.

Many of our difficulties in treatment can be directly attributed to excessive disharmony of the skeletal pattern. A recognition of such limitations forewarns the orthodontist of what he may expect if he undertakes treatment. It is much

more comforting to recognize this before starting a case than to find out after months of treatment that you are not getting the nice results that other cases produce.

The denture, however, presents relationships over which the orthodontist has considerable control in the three phases of orthodontic therapy, namely, interception of malocclusion, guiding the development of the denture, and correction of established malocclusions. The knowledge of variations of the relationship of the denture to the skeletal pattern in individuals with excellent occlusions is an aid in locating areas of disharmony in malocclusion. It points out quite clearly certain tooth movements that must be accomplished to recover harmony. Probably more important, serial cephalometric analysis of treated cases provides convincing evidence of what we really do with our treatment. It shows beyond question that our present abilities with an orthodontic appliance are not equal to restoring or maintaining balance and harmony of the component parts of the face without sacrificing dental units in many cases. It serves to clarify the possibilities and the limitations of appliance therapy.

The method of cephalometric analysis and the manner in which it is used in treatment planning are illustrated in the following cases.

VI. EXAMPLES OF THE USE OF LATERAL CEPHALOMETRIC X-RAYS IN CASE ANALYSIS

Patient B.—The first case (Fig. 17) is that of a 13-year-old girl with a Class I malocclusion, characterized by a crowding of the upper and lower incisors. The facial muscles are in good functional balance but the lips are full and tend to be protrusive.

TABLE VI

PATIENT B	1	2	CHANGES	CONTROL	GROUP
Age	13 yr., 6 mo.	14 yr., 11 mo.	1 and 2		
Balance of facial muscles	Poor	Good			
Nasopharynx	Clear				
	SKELETAL PATTERN				
Facial angle	88.5	90	+ 1.5	82	95
Angle of convexity	+10	+10	0	–85	+10
Mandibular plane	22	21.5	– 0.5	17	28
A-B plane to facial plane	– 6	– 7	– 1	– 9	0
Y axis	58	57	– 1	53	66
	DENTURE TO SKELETON				
Occlusal plane—F-H	+ 8.5	+ 7.5	– 1	+ 1.5	+14
1 to 1	117.5	145	+27.5	130	150.5
* 1 to mandibular plane	+14.5	+ 0.5	–14	– 8.5	+ 7
1 to occlusal plane	+28	+13	–15	+ 3.5	+20
1 to A-P	+ 7.5 mm.	+ 4 mm.	– 3.5 mm.	– 1 mm.	+ 5 mm.

All readings in degrees unless otherwise noted.
*Number of degrees of lingual (–) or labial (+) tipping.

Table VI shows the measurements of the skeletal and denture relationship of the case before and after treatment, the amount of change which has taken place, and a comparison with the control group.

The skeletal pattern of this case is good, being within the range of the controls. In the denture to skeleton readings, the last four measurements of the

first column are considerably outside of those for the controls and they indicate protrusion of the denture. The next column shows the measurements at the time of retention; all are within the range of the controls. Note that muscular balance has changed from poor to good. The third column shows the

A. B.

Fig. 17.—Photographs before (*A*) and after treatment (*B*) of patient B. Data, Table VI; tracings, Fig. 18; models, Fig. 19.

amount of change which has taken place. The 1.5° increase in the facial angle denotes a forward swing of the chin. The closing of the Y axis to Frankfort plane indicates that horizontal growth is increasing faster than vertical growth. This direction of facial growth is considered favorable.

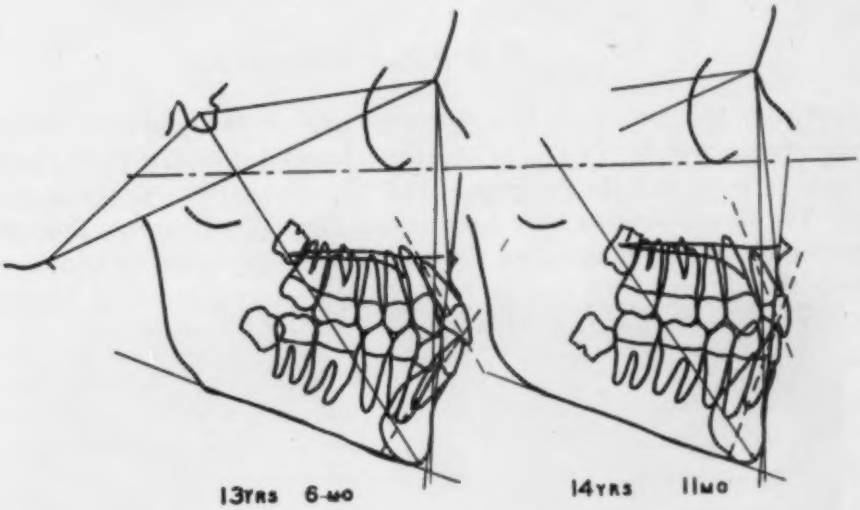


Fig. 18.—Tracing of patient B.

Fig. 19.—Models of patient B.

The principal changes in this case are found in the denture. The incisors are less procumbent by 27.5°; 14° of this change has occurred by uprighting the lower incisors and the remaining 13.5° by tipping the upper incisors lingually. The incisor crowns have been moved lingually 3.5 mm. Fig. 18 shows the tracing of the case illustrating the modifications produced by treatment. Fig. 19 shows the models of the case in Fig. 17 the photographs at the beginning of treatment and at the time of retention.

Patient A.—The next case, a 14-year-old girl, tells a different story (Table VII). A facial angle of 82° and an angle of convexity of +11.5° pictures a convex face with a recessive chin. The mandibular plane angle is large and the A-B plane relationship of maxillary denture base to mandibular denture base is not favorable. The Y axis angle of 67.5° is excessive and depicts a face in which the proportion of height to depth is greater than that found in the control group. This girl's skeletal pattern is considered poor.

The occlusal plane is steep, which is characteristic of cases with a recessive chin. The -2° of lingual tipping of the lower incisors is not often seen in association with this facial pattern. The greatest deviation of the denture measurements is an 11.5 mm. protrusion of the upper incisors. This is very excessive and is one of the principal corrections to be made in treatment. The influence of the skeletal and denture pattern upon facial form and muscle balance is evident in her photographs (Fig. 20).

TABLE VII

PATIENT A	1	2	CHANGES	CONTROL GROUP		
Age	14 yr., 5 mo.	16 yr., 1 mo.	1 and 2			
Balance of facial muscles	Poor	Improved				
Nasopharynx	Clear					
		SKELETAL PATTERN				
Facial angle	82	79	− 3	82	to	95
Angle of convexity	+11.5	+12	+ 0.5	− 8.5		+10
Mandibular plane	32.5	37	+ 4.5	17		28
A-B plane to facial plane	− 9	−10.5	− 1.5	− 9		0
Y axis	67.5	71	+ 3.5	53		66
		DENTURE TO SKELETON				
Occlusal plane—F-H	+ 16	+25	+ 9	+ 1.5		+14
1 to 1	124	144	+20	130		150.5
* 1 to mandibular plane	− 2	+ 4	+ 6	+ 7		− 8.5
1 to occlusal plane	+ 13	+ 14.5	+ 1.5	+ 3.5		+20
1 to A-P	+11.5 mm.	+ 2 mm.	− 9.5 mm.	+ 5		− 1

*Number of degrees of lingual (−) or labial (+) tipping.

You will recall that in the first case there was a favorable change in the skeletal pattern. This case differs in that the facial angle has decreased, that is, the chin is farther back than it was before treatment. This unfavorable change in pattern can be attributed principally to opening the bite which occurs when the mesiodistal relationship of molars is changed through the influence of intermaxillary traction. The evidence that the bite has been opened is seen in the 4.5° increase in the inclination of the mandibular plane and the 3.5° open-

ing of the Y axis angle. It might be of some comfort to know that follow-up headplates of this type of case usually show a rather rapid recovery, at least partial if not wholly of this pattern distortion due to bite opening, as the case is placed in retention and occlusion settles.

Fig. 20.—Photographs of patient A. Data, Table VII; tracings, Fig. 21; models, Fig. 22.

The changes in the denture relationship after treatment show a 9.5 mm. retraction of upper central incisors and a 20° reduction of the procumbence of the incisors. As the lower incisor was tipped forward 6°, this means the upper incisors were tipped lingually 26°.

The tracings (Fig. 21) illustrate the changes which have been described. The models are shown in Fig. 22 and the photographs in Fig. 20.

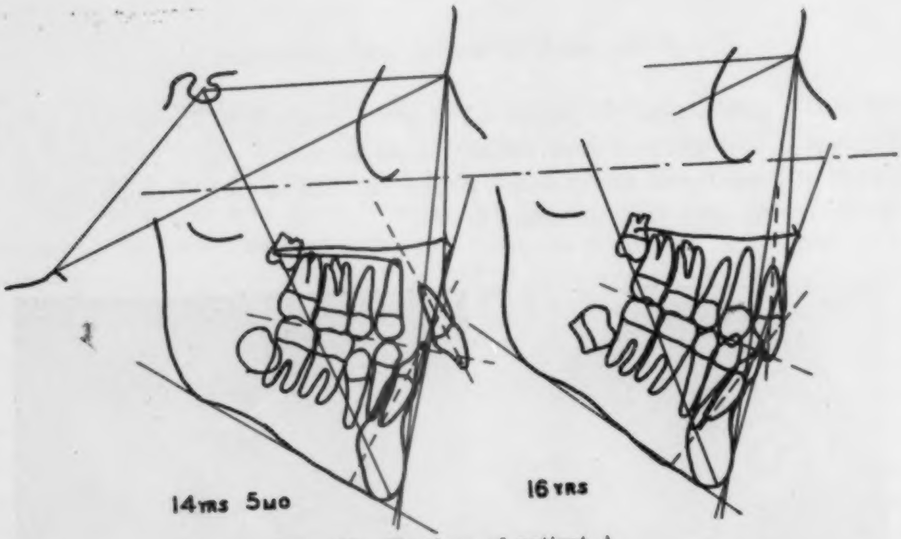


Fig. 21.—Tracings of patient A.

Fig. 22.—Models of patient A.

Patients C and D.—The next two cases are Class III malocclusions. The models look very similar (Figs. 23 and 24), but the photographs show the cases to be quite different (Figs. 25 and 26.)

The tracings (Fig. 27) of the man show a disharmony between the maxilla and the mandible, but the facial angle is not excessive, being 90°. The angle of convexity is -0.22. The disproportion in this case then can be said to be due to a distal position of the maxilla rather than an excessive forward position of the mandible to cranium. The malocclusion was so severe that it was considered untreatable by the usual orthodontic therapy, and sectioning of the rami was the method of treatment selected.

Fig. 23.

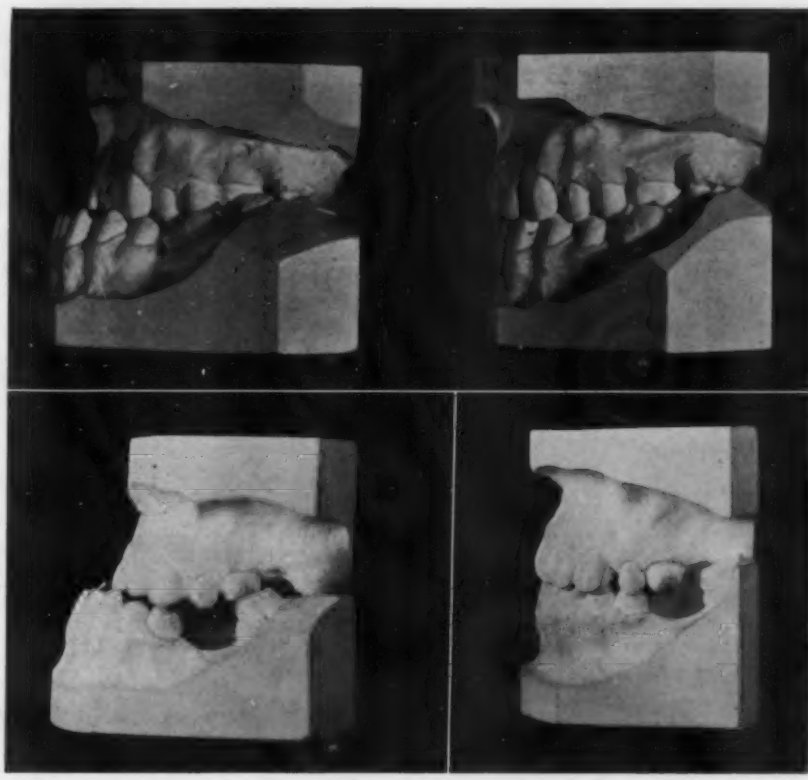


Fig. 24.

Fig. 23.—Models of patient C.
Fig. 24.—Models of patient D.

Patient C.—In the measurements of this case before treatment (Table VIII), you will note that only three readings are excessive, the angle of convexity, the A-B plane to facial plane, and the lingual tip of the lower central incisors. Setting the mandible distally has reduced the facial angle 4°, improved the angle of convexity 8°, and so changed the anteroposterior relationship of the denture bases that satisfactory occlusion was obtained and the strain of facial muscles relieved. Fig. 23 shows the models of the case and Fig. 25 the photographs.

TABLE VIII

PATIENT C	1	2	CHANGES	CONTROL GROUP	
Age	23 yr., 4 mo.	23 yr., 8 mo.	1 and 2		
Balance of facial muscles	Poor (tense)	Improved			
Nasopharynx	Clear				
	SKELETAL PATTERN				
Facial angle	90	86	–4	82 to	95
Angle of convexity	–22	–14	+8	– 8.5	+10
Mandibular plane	31	32	+1	17	28
A-B plane to facial plane	+11	+ 7	–4	– 9	0
Y axis	60.5	64.5	+4	53	66
	DENTURE TO SKELETON				
Occlusal plane—F-H	+10	+ 9	–1	+ 1.5	+14
$\underline{1\rvert}$ to $\overline{\lvert 1}$	149	149	0	130	150.5
* $\overline{\lvert 1}$ to mandibular plane	–18	–19	–1	– 8.5	+ 7
$\overline{\lvert 1}$ to occlusal plane	+ 4	+ 3	–1	+ 3.5	+20
$\underline{\lvert 1}$ to A-P	0 mm.	+ 5 mm.	+5 mm.	– 1 mm.	+ 5 mm.

*Number of degrees of lingual (–) or labial (+) tipping.

TABLE IX

PATIENT D	1	2	CHANGES	CONTROL GROUP	
Age	24 yr., 6 mo.	24 yr., 8 mo.	1 and 2		
Balance of facial muscles	Poor	Good			
Nasopharynx	Clear				
	SKELETAL PATTERN				
Facial angle	96	88.5	– 7.5	82 to	95
Angle of convexity	–22	–3	+19	– 8.5	+10
Mandibular plane	34	43	+ 9	17	28
A-B plane to facial plane	+12	0	–12	– 9	0
Y axis	56	64.5	+ 8.5	53	66
	DENTURE TO SKELETON				
Occlusal plane—F-H	+13	+16	+ 3	+15	+14
$\underline{\lvert 1}$ to $\overline{\lvert 1}$	143	139	– 4	130	150.5
* $\overline{\lvert 1}$ to mandibular plane	–25	–26	+ 1	– 8.5	+ 7
$\overline{\lvert 1}$ to occlusal plane	–4.5	+2	+ 6.5	+ 3.5	+20
$\underline{\lvert 1}$ to A-P	+1 mm.	+6 mm.	+ 5 mm.	– 1 mm.	+ 5 mm.

*Number of degrees of lingual (–) or labial (+) tipping.

Patient D.—The tracings of the other case (Fig. 28) show a classical Class III malocclusion. This too was treated by sectioning of the rami. The tracing on the right shows the case seven weeks after the operation.

The measurements (Table IX) show a high facial angle of 96° as compared with 90° for the preceding case. To picture better what this means, each degree of facial angle represents about 2.5 mm. in anteroposterior position of the chin. Both cases show the same degree of concavity of the face and similar disproportionate relationship of the denture bases. This patient has a protrusive mandible which is the principal cause of the disproportion of the facial pattern. This is borne out in an examination of the readings subsequent to treatment, for now the pattern is within the range of the control series except for the mandibular plane angle which has been increased 10°.

The change in the axial inclination of the incisors is due to a short period of appliance treatment preceding the surgery, but the change of the distance

of the upper incisors to the A-P plane is principally the result of moving the body of the mandible distally. The models of the case are shown in Fig. 24 and the photographs in Fig. 26.

Fig. 25.

Fig. 26.

Fig. 25.—Photographs of patient C. Data, Table VIII; tracings, Fig. 27; models, Fig. 23.
Fig. 26.—Photographs of patient D. Data, Table IX; tracings, Fig. 28; models, Fig. 24.

The previous cases were not selected for any particular excellence in treatment but rather because they represent excessive readings of various cephalometric relationships and serve well to illustrate this method of appraisal. Case A has now been free of retention for a year and gives every indication of being stable. Case B, treated at the same time as A, is still in retention and shows minor relapse tendencies. Cases C and D have been free of appliance for several years and have maintained the esthetic and functional improvement gained by treatment.

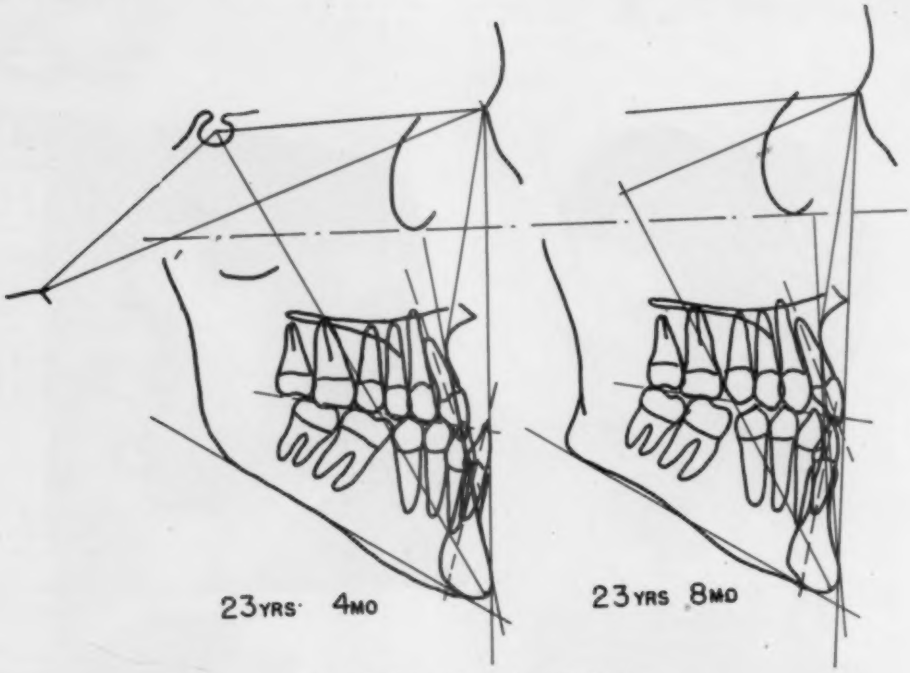


Fig. 27.—Tracings of patient C.

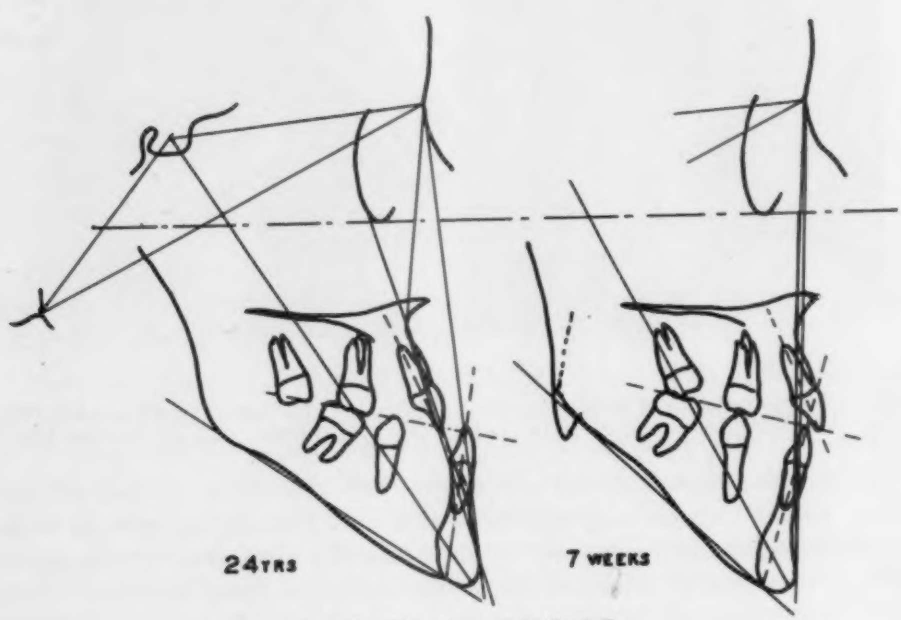


Fig. 28.—Tracings of patient D.

VII. SUMMARY

What constitutes harmony and balance of the component parts of the face, namely: the skeletal framework, the denture, and the overlying musculature, has for many years commanded the attention of the research investigator, the teacher, and the clinician. A satisfactory solution is most difficult to attain, one being faced with the innumerable variations of type, as well as the unfolding of the facial pattern from the infant to the adult.

The results of this study of twenty individuals with excellent occlusions and a review of similar investigations appear to warrant the following conclusions:

(1) There is a facial pattern that represents mean or average form for individuals possessing excellent occlusions.

(2) There is a notable deviation on both sides of the mean findings of the facial pattern. These represent the usual variation one must reckon with when appraising balance and harmony.

(3) Excessive deviations of the means and extremes found in this study usually express abnormalities of relationship which will be evident as disharmonies or imbalance of particular areas.

(4) The skeletal pattern in the lateral aspect may be described in figures and be appraised as good or bad according to the amount of deviation of the readings from the known mean pattern. Such information can be of considerable help in forming a prognosis of treatment.

(5) The relationship of the denture of any case to its skeletal pattern can likewise be compared with known relationships of good balance and harmony. Such analysis tends to point out the desirable tooth movement indicated in treatment.

(6) Serial study of cases by this method permits definite expression of anteroposterior and vertical changes induced by treatment and those occurring during retention, as well as those changes that may be attributed to growth and development.

(7) This method of cephalometric analysis has been tested for three years in the author's practice as well as in the graduate department of orthodontics at the University of Illinois. In the last year the orthodontics departments of the University of California, Northwestern, and Indiana have cooperated in testing its clinical and teaching value. Out of these experiences has come one particularly important comment: *The ten figures used in the appraisal do describe skeletal and denture relationships but single readings are not so important; what counts is the manner in which they all fit together and their correlation with type, function, and esthetics.*

Acknowledgment is made to Mooseheart from where many of the excellent occlusion records were obtained, to Dr. Allan G. Brodie for his counsel, and to Dr. A. W. Moore for computing the statistical data of the study, most of which for the sake of simplicity has not been included in this report.

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Errata

In the article by Dr. James David McCoy entitled "The Consultative Period" in the August issue of the JOURNAL, on page 637, last paragraph, the first sentence should read:

> Where treatment is indicated most parents will wish to know the approximate expense entailed so that this brings up the necessity of discussing the business arrangement.

A comma was incorrectly placed after the word *most* by the publisher.

In the September issue of the JOURNAL in the "Report of the Research Committee of the American Association of Orthodontists," under "First Honorable Mention," page 780, and under "Papers Submitted in the Prize Essay Contest," page 781, Dr. Allen C. Brader's address should read:

1115 Walnut Street,
Allentown, Pennsylvania.

THE AGE FACTOR IN TREATMENT PLANNING

W. Wayne White, D.D.S., Kansas City, Mo.

"WHEN smart men disagree, no one knows." The orthodontic literature reveals how long and how much the orthodontists have disagreed on the most favorable age for orthodontic treatment. The age factor in treatment planning is not a seriously disturbing problem when the patient is presented for his first orthodontic contact in the early teen age. By this time the second molars have erupted; the individual growth pattern is well established; the dentofacial deformity has nearly reached its most extreme proportion; there are sufficient teeth erupted to receive nearly any type of appliance and the patient has seldom attained any position in business or society which makes the wearing of any type of appliance intolerable.

The age factor becomes a perplexing problem when there is doubt as to whether the patient is either too young or too old to respond favorably to treatment. By far, the more baffling problems arise when the patient presents at one of the younger ages.

In the early part of the present century, the teachings of Edward H. Angle very effectively turned the orthodontic thought to believing that the proper positioning of the teeth in the proper functional relationship would very definitely induce the basal bone and other tooth-supporting tissues to grow to balanced proportions. If this were true, early treatment would be the logical answer. In Angle's *Malocclusion of the Teeth,* seventh edition,[1] he says, "The Author is more and more impressed with the advantages of beginning the treatment early, just as soon as malocclusion is manifest."

Calvin Case[3] in his last paper, written shortly before his death in 1923, made a plea to the orthodontists to refrain from starting treatment too early. In this paper he says:

> With few exceptions, I never begin the early regulation of children's teeth much before the eruption of the second molars—for one reason, you have them on your hands, or rather they have you on their hands during the time of life when they should be running free; whereas, there is no case in orthodontia, however dentally or facially deformed, which cannot be corrected with greater assurance of success, and often with far less difficulty, if you wait until after the eruption of the second permanent molars. This has been proved in hundreds of cases in my practice.

These contrasting opinions of two experienced students and teachers of orthodontics were a stimulation to further study and investigations. It was important to know not who was right but what was true.

Presented at the Forty-fourth Annual Meeting of the American Association of Orthodontists, Columbus, Ohio, April 26-29, 1948.

Dr. A. LeRoy Johnson presented a very enlightening paper in 1924 entitled "Early Orthodontic Treatment." Several of his statements are significant and perhaps just as appropriate today as then. In his opening paragraph he said:

It seems to me that this question of the time of treatment should be given serious consideration. One's attitude toward it reflects the concept of principles fundamental in orthodontia, hence there should be more unanimity of opinion than there now is. In fact, I know of no question relative to orthodontic procedure that can be discussed more profitably at this time.

How does that statement fit the situation today?

The problem of the time of treatment is still a timely subject for discussion. One's attitude toward it still reflects his concept of fundamental principles in orthodontics. During the intervening years since 1924, many orthodontists have changed their concept of some of the fundamental principles of orthodontics, and in so doing have changed their attitude toward the more favorable time for treatment. Yet, it is doubtful if there is greater unanimity of opinion now than there was twenty-four years ago!

It is obvious that one cannot select the time for treatment until he has determined what the treatment is to be, what he expects the treatment to accomplish, and has learned something of the individual growth tendencies of the patient under consideration. The timing of treatment is inseparably linked with diagnosis.

Johnson remarked in his paper, "With the increase in knowledge, diagnosis is becoming more difficult."

The increase in knowledge since 1924 has been tremendous. Clint Howard led one of the first of a long series of investigations into the correlation of jaw growth with skeletal growth and the influence of hormones on the growth of the jaws and other bones. The studies of jaw growth through the medium of lateral head roentgenograms made by cephalometric techniques, and reported by Broadbent, McDowell, Higley, Brodie, and others have greatly increased orthodontic knowledge. The publication on bone growth by Sicher, and on tissue changes by Oppenheim, and the reports on genetic studies by Johnson and Hughes have made valuable contributions to the store of orthodontic knowledge.

The knowledge gained from these and the many other valuable contributions to the field of orthodontics has tended to establish a fuller concept of the many variations encountered in treating individuals.

Probably there has been no error so frequently or consistently made by nearly all orthodontists as the one of comparing cases on the basis of their occlusion. Angle's classification was based on occlusion. Orthodontists have been slow to reject it, perhaps one reason being that they have not been given another that is universally acceptable.

Angle[1] condemned the practice of planning the treatment for the individual case according to the judgment of the operator. Rather, he insisted on classifying the case and then treating it according to the prescribed treatment for that class.

The best time for orthodontic treatment cannot be determined by the classification of occlusion. There is no classification available that serves to clarify this most important problem. In discussing this, Hughes concludes: "The difference in treatment will be proportional to the differences in individuals and not proportional to the differences in the classifications of occlusion." If the treatment varies proportional to differences in individuals, the time of treatment must vary accordingly. It would be well to follow the conclusions of Waldo[16]: "(1) That we consider our patients as individuals; (2) that we attempt to recognize their differences; (3) that, however we interpret these differences for the moment, we set out to learn more about them."

It is not the variations of individual patients that create all of the perplexities. Probably, the more disturbing situation arises from the variation in the thinking among the individual orthodontists. There can be little progress toward agreement on the proper time to start treatment until there is further agreement on the objectives, the possibilities, and the limitations of treatment.

Johnson recognized this principle in his paper on early orthodontic treatment. Another pertinent paragraph from his paper of 1924 is:

> Today we no longer labor under the belief that by moving teeth we make the jaws grow. We would correct malocclusion of the teeth because we believe that by doing so we create a more favorable environment for the supporting structures, and so permit them to develop to the fullest expression of their inherent capabilities. We know that there are cases of malocclusion that cannot be corrected by any of our present day methods of procedure. No orthodontist of experience will question such a statement. We are not in a position to progress until we have discovered that we have limitations.

That point of view is probably acceptable to a larger proportion of the orthodontists today than when it was read in 1924. At that time the majority were unwilling to accept such strict limitations. Today, this same statement would probably be interpreted by some orthodontists as being too liberal.

Recently there have been some who have presented evidence and interpreted it to indicate that an orthodontist can neither widen nor lengthen the dental arch and maintain it; that he cannot retract molars and maintain them in retracted positions[11]; that he cannot change rest position of the mandible nor maintain the occlusal surfaces in closer relationship to each other than a distance of approximately 3 mm. when the mandible is in rest position.[15]

If by treatment the orthodontist believes he can have no influence on the growth of basal bone, and if he believes he cannot successfully retract molars or expand arches, and if he believes he cannot depress teeth or stimulate eruption, and can have no effect on the position of the mandible in rest position, it would seem wise for him to wait until all the teeth had erupted, excepting third molars and impacted teeth (if any), before starting treatment. Under such a concept, his objective would be to reduce the tooth structure to an amount that could be aligned within the limits of the alveolar process present or, in case of insufficient tooth structure, supply artificial substitutes. Higley[6] refers to this very limited concept as the "prosthetic attitude."

There is, however, some evidence to indicate that living bone, especially during growth, is flexible and can be distorted or caused to change its form by

applied pressures. Davenport[4] reports results of experimental work in this field. He draws the following conclusions:

Though the bones of the head seem rigid, the living bone is more or less plastic even to adulthood. The form of the infant's head is modifiable by gravity, but unless the modifying agent acts for a long time, the effect is largely temporary. The degree and permanency of the effect produced depends upon the degree of cooperation between external and internal factors. Large results are achieved if the environment tends to produce change in line with the genetic tendencies. And so in orthodontic practice greater results are to be expected when one knows (perhaps through acquaintance with other members of the family) the direction of the genetic development in which the jaw is proceeding.

Taylor[14] expresses an opinion, which is concurred in by others, that early treatment of Class II cases often results in bimaxillary protrusions. This indicates that the treatment is wrong in type rather than that it has no permanent effect.

Hughes[7] says, regarding alveolar processes:

The amount of alveolar bone is largely hereditary as is its basic distribution upon the maxilla and mandible. It would take too long to list the many variations and changes which occur within the alveoli. Sufficient to say they are many and a very high percentage have little or no genetic basis. The bones are both nurturally and mechanically plastic and within the limits of amount many types of modification can be instituted.

As long as these differences of opinion concerning the fundamental problems of treatment exist there can be no acceptable basis upon which the time for treatment can be definitely selected.

In attempting to state any general rule on the time of treatment, it seems that there is no way to avoid two variables. The selection of the more favorable time for treatment must vary, not only proportional to the differences in the individuals to be treated, but vary also, proportional to the opinion and concept of the individuals planning the treatment.

The individual orthodontist must learn as much as is pertinent and available concerning the individual patient and, in the light of his own concept of what is possible and desirable, decide if and when treatment is advisable.

The problem is not easy for either teacher or student. Perhaps those of long experience are best prepared to think through the confusion. Johnson might well repeat his words of twenty-four years ago, "There ought to be more unanimity of opinion than there now is."

It is unfortunate that some degree of antagonism has developed between groups of orthodontists supporting different opinions. An attitude of tolerance and friendly cooperation in the search for the true facts would be more progressive.

When prominent orthodontists bitterly criticize the members of their own profession and insinuate that they are both ignorant and dishonest, they create more ill will among the orthodontists and add to the confusion of the students of orthodontists.

The effects are even more damaging when this criticism is published in journals read by the general dentists. Recently there appeared in the opening

paragraph of a paper published in the *Journal of the American Dental Association* the following remark: "If the prevailing practice is to be taken as the answer, the time to start treatment is when the patient arrives at the Orthodontist's office."[5]

Another article published recently opened with this statement: "Fifty per-cent of the children under nine years of age, who are wearing Orthodontic appliances, do not need them."[14]

Should the practitioner of general dentistry be influenced to believe he is protecting his patients from charlatanism if he succeeds in keeping them from an orthodontist until they are past 12 years of age?

If the orthodontist is to fit the proper time and plan of treatment to the individual patient, he needs to have the patient available when he can do the most good with the least time and effort. Frequently he needs to have a few years of observation with records of growth changes in order to understand better the individual tendencies of the patient. The practice of observing patients from as early as possible, in order to learn better their individual growth pattern and enable the orthodontist to use better judgment in timing and planning treatment, has been stressed by Dr. George Moore. It should be given thorough consideration in all programs for teaching orthodontics.

Frequently, patients who were advised to wait by their family dentist present to the orthodontist with a condition which could have been treated with less time and expense at an earlier date. The orthodontist should be given the responsibility of deciding the time when treatment should be started.

Few, if any, orthodontists of today would advocate that mechanical treatment should be started on all patients as soon as malocclusion was manifest. There cannot conceivably be any who would advise waiting in all cases until the second permanent molars had erupted. The problem is in differentiating between the ones that should be treated early and the ones that should wait until a later period. In some cases the decision is easy. In some cases it requires the careful weighing of the advantages and disadvantages in order to make a decision.

Hughes[7] has stated that the source of a variation, whether from heredity or from environment, does not imply the amount of change one may obtain by treatment. While this may be true, the orthodontist generally believes that variations caused by environmental factors which may become inactive are less persistent in re-establishing themselves after treatment than those of inherited origin. If one believes the causative factors can be removed or made inactive, he is likely to believe that early treatment will be more satisfactory.

The patient is likely to show greater appreciation for the service if the condition is permitted to reach its most disfiguring proportion before corrective measures are instituted. If the orthodontist planned for his own welfare only, he would usually wait for this opportunity.

However, if a better result can be obtained by a period of early treatment which prevents the condition from becoming so extreme, it is the duty of the orthodontist to offer his service at the most opportune time. This seems to be what Nagamoto[10] had in mind when he said at the Southwestern meeting in

Wichita, "There is no excuse for a well meaning Orthodontist to ignore cases before him, even though the ease and expediency of treating them later is known."

Hughes[7] reports that there is evidence for a wider flexibility of tissues during periods of rapid growth and a narrower tolerance during periods of slow growth. Howard also pointed this out years ago. This principle should be kept in mind when planning treatment. Chronological age is not a dependable guide. Knowledge of the individual patient is essential. A period of observation preceding treatment furnishes some information on this point.

Those who elect to treat some cases for a period of time at an early age, i.e., before the greater proportion of growth has taken place in the dentofacial area, do so with the expectation that such treatment will, in a very limited number of cases, eliminate a sufficient number of causative factors in a developing malocclusion to make later treatment unnecessary and, in a larger number of cases, that it will be effective in preventing the undesirable arrangement of dentofacial tissues from reaching such extreme proportions. This approach to the problem requires good judgment plus the ability to use a variety of appliances adaptable to various ages and conditions. The severest crticism of this idea seems to come from those who use one type or method of treatment which is not applicable to the variation in mixed dentitions.

Recently there has been much said and written about the type of case in which the total amount of tooth structure is not in harmony with the size and pattern of the basal bone supporting the teeth and alveolar process. When this disharmony exists to such a degree that extractions are warranted, and the case is not complicated by other serious factors, it is suggested that the time to start treatment would be when the teeth to be moved into the spaces left by extractions are erupted and the roots so completely formed that movement will be of minimal disturbance to the development of the roots of these teeth.

There are many cases of malocclusion in which the disharmony of size and shape of the teeth with basal bone is not of prime consideration. In these cases the time selected for starting treatment depends on a differential analysis.

Oppenheim points out that the greatest amount of bony change comes as a result of light pressures applied over a long period of time. This is the type of pressure resulting from cuspal interlocking in occlusion, tongue and lip function, and pressure habits.

In most cases the orthodontist can be effective in changing the direction of the influence of cusp relationship pressures, contact pressures, and undesirable habit pressures. To some degree, he may improve the influence of muscular pressures in functional action.

When these light pressures exerted by the musculature surrounding the teeth and the occlusal and the contact pressures of the teeth are cooperating with natural growth tendencies toward a desirable end result, the orthodontist is not needed.

When all of these pressures are acting to oppose an undesirable growth tendency, it is doubtful if orthodontic treatment will be of much value.

When some or all of these pressures are acting to accelerate or intensify a growth tendency that is undesirable, the orthodontist is needed most ur-

gently. This situation frequently calls for treatment in several periods. The first period of treatment should be started early and each period so timed that the desired influence is active at the times when growth is most rapid in the individual being treated.

When some or all of these pressures are acting to oppose a desirable growth tendency, treatment should be instituted early. Unless new habits are developed or old ones renewed which unfavorably influence natural tendencies, later treatment will probably not be needed.

When the situation is doubtful, obesrvation with records of growth is advisable. It is better to apply the proper treatment late than the wrong treatment early.

Fig. 1.

Fig. 2.

A discussion of a few photographs showing some individual cases may offer an opportunity for more personal opinion. The extent to which teeth can be driven into extreme positions by the force of interlocking cusps in occlusion is illustrated in this case (Fig. 1). The mandible swings sharply to the left in closing. The embedded second deciduous molar on the right side (Fig. 2) has held the first premolar and first molar farther apart than a normal-sized second premolar would have done. The contact force is lower on the permanent tooth on either side of the deciduous molar and permits the crowns of these teeth to tip toward each other. As this tipping occurred, the roots grew farther apart. The distance from the tip of the root of the first premolar to the tip of the mesial root of the first molar on the right side measures 10 mm. greater than on the left side where the second premolar is present. A measurement

from the menton to the gonial angle on the right side is 10 mm. greater than on the left side. This means that there must have been a greater growth of the mandible on the right side than on the left. It is difficult to believe that this difference is all due to inherited growth pattern. The extent to which a local factor starting early and acting over a long period of time can influence the growth of basal bone is not known. It is suggested that early treatment in this case could have prevented a considerable amount of the deformity and given a more favorable result than could be obtained at this late age.

Cross-bites need early treatment (Fig. 3). The pressure of the cusps of the teeth locking in cross-bite in occlusion tends to make the case grow more extreme. Even if the individual's growth pattern is such that the cross-bite is likely to recur, it should be treated early and again later if and when it does recur. Breitner[2] has shown that buccal movement of the deciduous molars does have an influence on the position of the developing premolar crowns. One should not necessarily wait until all permanent teeth have erupted before treating cross-bite cases.

Fig. 3.—Three typical cases showing cross-bites. Early treatment recommended.

Supernumerary teeth may interfere with the normal eruption of permanent teeth. The more usual location is in the path of the central incisors, but occasionally the cuspid or other teeth are blocked out by these extra formations. An x-ray survey should be made of any tardy eruption, and if supernumerary teeth are found they should be removed as soon as possible. Fig. 4, *A* shows casts of a boy with supernumerary erupting in place of maxillary left central incisor; *B* shows casts made after the supernumerary had been extracted. The right central incisor has started to move to the left. The case needs treatment to open and maintain the space until the left central incisor and lateral incisor erupt.

Another case (Fig. 4, *C*) shows casts of a girl 14 years of age, with maxillary left central incisor impacted over unerupted supernumerary. The space is partially closed. This girl suffered the embarrassment of one year in high school with this ugly space showing because her parents thought nothing could be done at a younger age.

Fig. 4, *D* shows casts of a 13-year-old boy with unerupted maxillary right central incisor. The x-ray pictures (Fig. 5) tell the story of the management of this case. In September, 1946, the family dentist removed the deciduous central incisor and advised waiting and watching. Nine months later, he made another picture and advised the removal of the supernumerary. This was done

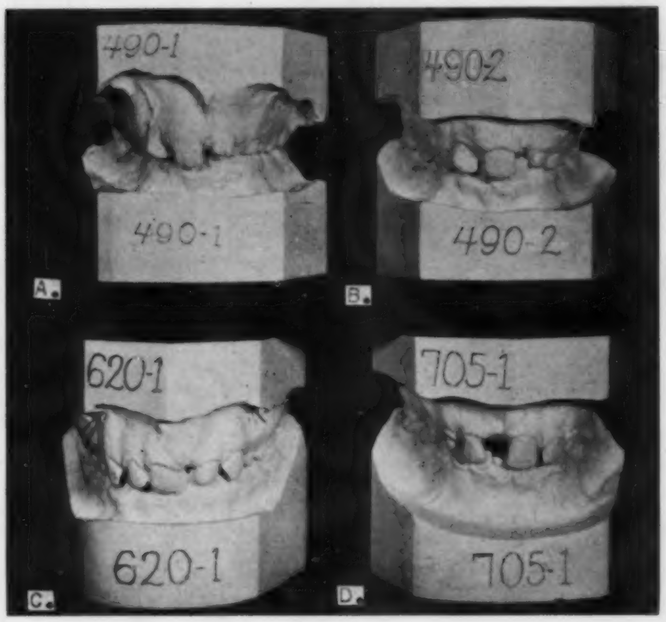
490-1
490-1
A.
490-2
490-2
B.
620-1
620-1
C.
705-1
705-1
D.

Fig. 4.

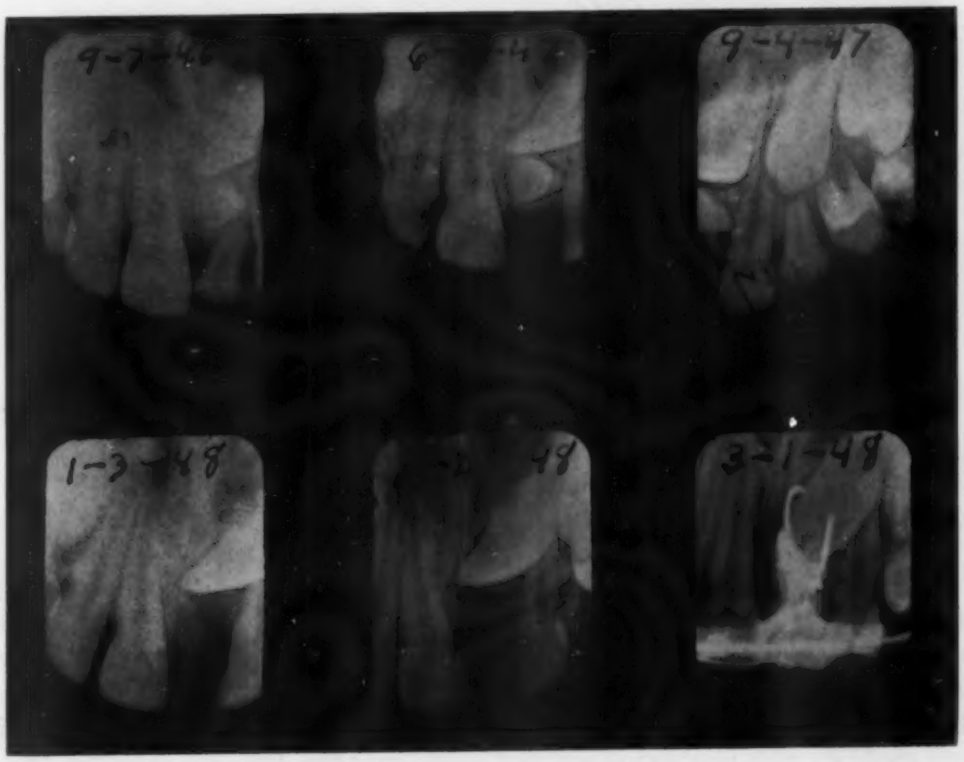
9-7-46
9-4-47
1-3-48
3-1-48

Fig. 5.

and another period of waiting was advised. In January, 1948, the permanent central incisor had not progressed in eruption. The case was then referred to an orthodontist. During all of this delay the root of this central incisor was growing in the wrong direction, making the tilting of this tooth into a vertical position more difficult. The early removal of a supernumerary tooth forming under the right cuspid (Fig. 6) enabled the cuspid to erupt more nearly into normal position.

Fig. 6.—A small supernumerary forming under right maxillary cuspid. Prompt removal is indicated.

A.

B.

Fig. 7.

The type of case shown in Fig. 7 is chiefly a growth problem. Probably the better service is to keep records and watch the growth changes without any mechanical treatment until the time when one can see a more definite need for mechanical help. The patient does not retract the mandible in rest position. In rest position the teeth are out of occlusion. There seems to be nothing one could do with mechanical aid that would give the dentofacial tissues greater freedom to grow toward their natural pattern. It is doubtful if one should attempt to interfere with the natural growth tendencies at this age.

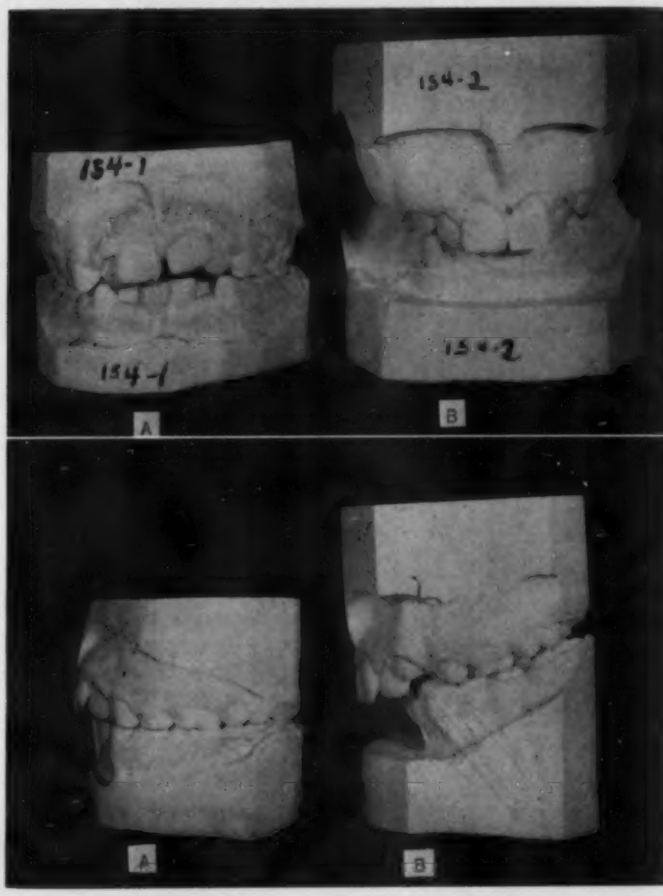

Fig. 8.

A. *B.*

Fig. 9.

The case of B. T. (Fig. 8) presented for treatment at 7 years, 6 months of age. Both she and her mother were disappointed when advised to wait for several years. Three years later (Fig. 8*B*) the patient was even more anxious for some improvement. The maxillary first molars were banded and occipital

Fig. 10.

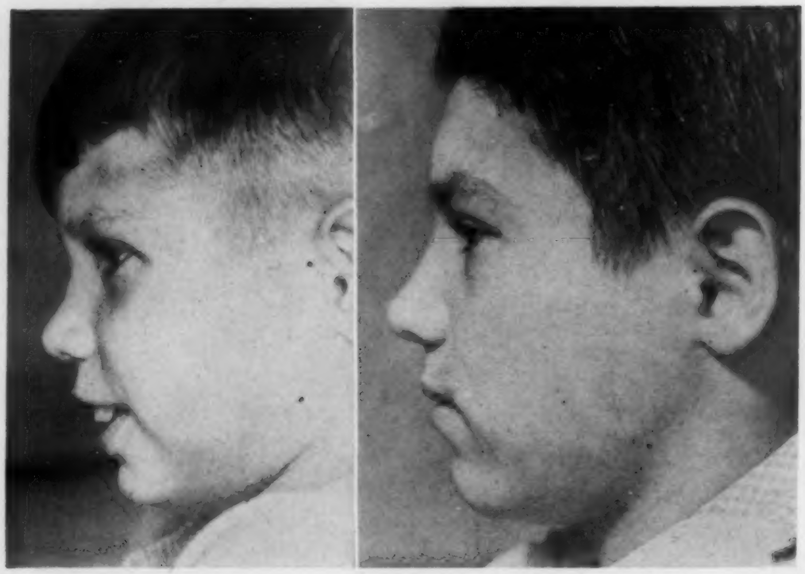

Fig. 11.

anchorage used to apply retracting force at night. In the lower arch a plain lingual round wire arch passing through horizontal tubes with coil springs pressing against the tubes for distal movement of the molars was used. All second permanent molars were removed. X-ray pictures revealed that the third

molars were developing into well-formed teeth. All treatment was discontinued after 12 years of age. The results are shown in Fig. 9, *A* and *B*. The patient was happy with the result and pleased that she did not need to wear conspicuous appliances during her high school days.

Large teeth can appear beautiful if set well in the arch. It is usually their prominence or crowded arrangement that makes them displeasing. Fig. 10 shows the pleasing smile of the patient whose casts were shown in Figs. 8 and 9.

In cases where the maxillary permanent incisors erupt into such positions that the lips cannot assume normal rest positions or properly serve their normal functions, an early period of treatment may be of value. Such a case is shown in Fig. 11, *A*. This boy presented for treatment at 8 years of age. A period of treatment of approximately one year was instituted with plans made for a second period of similar length at approximately 12 years of age. Fig. 11, *B* shows lips in rest position at 14 years of age. Good lip tone in rest position is an important factor in retention of teeth following treatment.

Any orthodontist of experience has seen cases which responded well whether treated early or late. He has also seen some that gave poor response to either early or late treatment. The problem of the time of treatment is one requiring good judgment and has to be considered along with diagnosis, treatment planning, individual limitations, and desirable modifications.

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THE TISSUES AND CHANGES INVOLVED IN ORTHODONTIC TOOTH MOVEMENTS

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IT IS essential to consider first the physiology of the attachment apparatus before attempting a discussion of the tissues and changes in orthodontic tooth movement. With attachment apparatus we include cementum, periodontal membrane, and bone, for all three function in unity.

Cementum,[1] fortunately, is much more resistant to resorption than bone because of its peculiar pattern of growth, that of the slow but continuous cementoid formation. It will, however, and does become resorbed[2, 3, 4] in smaller or larger areas following tears of the periodontal fibers, various traumatic injuries, and the stronger forces of an orthodontic appliance which moves the tooth to the limit of the periodontal membrane space. It has been stated[2, 3] that every tooth moved by an orthodontic appliance has microscopic resorption areas that become repaired after treatment is discontinued. The orthodontist need not be too much concerned with these areas. To prevent cemental resorption, the orthodontist may be guided by this rule[5]: So long as the tooth moves in the periodontal membrane space, minimal resorption will occur.

From a practical viewpoint for the orthodontist, the fibers of the periodontal membrane should be thought of as belonging to two groups, one attached tooth-to-bone and the other attached tooth-to-tooth or tooth-to-subepithelial connective tissue. We may alter the arrangement and attachment of the former group when including changes in bone, but we are not so certain about being able to alter the latter group. The subepithelial tissues do not conform to tooth movement as does bone; hence this may be a factor in relapse.

From a functional viewpoint, the oblique fibers of the periodontal membrane are highly important. They comprise the most numerous fibers and are so designed that their attachment is higher on the alveolar bone side than on the tooth. These fibers act in the capacity of a suspensory ligament, and when stresses are applied to them in a normal direction, pull is registered. Pull on bone and on fibrous tissue will cause both to increase in thickness as a compensatory measure to resist the increased function thrust upon them. This is probably why depression of teeth in their sockets is questionable.

Bone is constantly undergoing reorganization and reconstruction alterations. Probably alveolar bone is required to change more often than other bones. A permanent type of bone requires time for the completion of its complicated pattern. Concomitant growth of bone, the shedding and eruption of teeth, the alignment of teeth, readjustment by orthodontic treatment, readjustment when teeth are lost, and wear and tear demand a makeshift structure to

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act in the capacity of a temporary support. We are, therefore, endowed with two kinds of alveolar bone: one a temporary, the bundle bone; the other a more permanent, the lamellated bone. This is clearly observed in the continuous physiologic movement[6] of the teeth toward the median line as a result of the wearing away of contact points. The mesial aspect of a tooth socket shows resorption, while the distal aspect shows apposition by bundle bone. This process occurs slowly with alternating periods of tooth movement and resorption, followed by rest and repair. In this fashion the fibers of the periodontal membrane are reorganized and reattached. This is Nature's orthodontic appliance to take up the slack. Had these facts been known and applied earlier, there would not have been so much controversy about tissue changes in orthodontics, for the answers are observed here.

When a sufficient thickness of bundle bone is laid down, reconstruction changes occur resulting in its substitution by lamellated bone. A similar change takes place during the retention period of treatment. It follows that sufficient time for this reconstruction period should be allowed before the retaining appliances are discontinued. The time necessary is not known for human beings; only animal experiments are available.

The mechanism of bony deposition is important. First, an osteoid material is formed which soon becomes calcified. A similar pattern obtains in cementum. It has been shown that both osteoid and cementoid[7] are more resistant to resorption than are completely calcified bone and cementum. The implication of this finding is that tooth movement should be slowly continuous rather than intermittent. When intermittent, osteoid may form, thereby prolonging treatment time. This, however, only applies to moving teeth relatively short distances. If teeth are to be moved greater distances, it might be feasible to use intermittent force to permit a large area of bundle bone to become reconstructed with lamellated bone sometime during the course of treatment. This can be the only answer to the controversy over continuous versus intermittent forces. Both have their place. Since it has been shown by cephalometric studies[8] that teeth are not actually moved in their sockets as much as they seem to be, probably light continuous force is the more desirable choice.

Both bone and periodontal membrane are thick when functioning properly (Wolff's law for bone), but when out of function a disuse atrophy[9] occurs. It is not known whether there is any difference in the behavior of both toward resorption and repair incident to orthodontic procedures.

The orthodontist and the periodontist have similar problems, for both are concerned with the biology of the attachment apparatus. Teeth may be subjected to two kinds of stresses, vertical and horizontal. Our attachment apparatus was designed to resist vertical stresses better. The periodontist is more concerned with horizontal stresses, and the orthodontist uses this type of stress with his appliances. Both the orthodontist and the periodontist have benefited from experimental research concerning the effect of these stresses directed against teeth. It is here that we enter into the controversy of the location of the fulcrum[10] of a tooth. When a tooth is tipped by a horizontal stress, the fulcrum

is described as being just below the center of the alveolus. When strong force is used, this holds true. When light forces are used the fulcrum is said to appear more apical.[11] Since bodily movement of teeth is now possible with the newer orthodontic appliances, the location of the fulcrum is not as important as it once appeared to be.

The effect of varying degrees of force used with orthodontic movement of teeth has been reported, and a study of tissue sections (not too numerous) reveals that fundamentally three types of reactions follow the use of light, medium, and strong forces, respectively. The basic effect of strong forces[4] is a crushing and necrosis of the periodontal membrane, and tooth movement ceases until the injured tissues are removed by undermining resorption.

The injured tissues may be cementum, as well as bone and the periodontal fibers. Medium forces do not cause crushing injuries, but stimulate the formation of bony trabeculae[12] in the direction of the force, which are later reconstructed to a lamellated bone. Light forces are most ideal,[13] for they stimulate both bundle and lamellated bone so that tooth movement, bundle bone, and reconstruction go hand in hand. The period of retention is lessened following the use of light forces.

There are six kinds of movement of teeth in orthodontic treatment: tipping, bodily movement, elongation, depression, rotation, and the closure of a space following tooth removal.

Tipping is the more common type of tooth movement. It occurs as a complication of all other tooth movements. On the pressure side bone is resorbed. On the side of pull three types of bony growth may occur. With light force, layers of bundle only are formed. With strong forces, bony trabeculae are built in the direction of the applied force.

These bony trabeculae follow the course of the stretched fiber bundles of the periodontal membrane to prevent tearing. With medium force, a combination of the two occurs. If tooth movement is in a labial direction and is not too rapid, a compensating labial plate[1] is built by osteophytes, which is an emergency and rapid reinforcement of the alveolar process. This compensating bone is a common physiologic response of all bones to various stimuli which tend to weaken their structure. With strong forces, on the pressure side, the attachment apparatus becomes crushed and necrotic and all movement ceases until undermining resorption eliminates the damaged tissues. When the tension ceases, bone resorption on the pressure side and bone formation on the tension side cease. Now reconstruction follows. It has been found in animal experiments[5] that a relatively light force acting over a period of time no greater than in some cases in which stronger forces were employed resulted in a greater movement of the tooth and produced more outstanding changes.

Some type of retaining appliance is essential, and retaining appliances should be designed in a manner that will permit the individual teeth to be immediately subjected to functional stresses.[14] In a study of different types of injuries to teeth, many varieties of adaptability of the attachment apparatus

were found. This suggests that a more rapid reconstruction process is instituted in response to functional stresses. Oppenheim[15] found greater reconstruction changes in two teeth that had been moved and left alone in comparison to two other teeth that had been moved but rigidly retained.

Bodily movement is comparable to tipping. The same changes occur, but over broader surface areas. It is a slower process and unless one employs a well-stabilized and rigid appliance, tipping is a complication. It is said that too severe a bodily movement will result in pulpal injury far more often than in tipping.

Available data on the reaction of the pulp to orthodontic appliances differ, some claiming severe, others mild or no injury. The report of Markus[16] is interesting. By using an electric current in appraising pulpal changes as the result of pressure against teeth, he found that the threshold of stimulation was lowered, which is indicative of pulpal irritation.

These changes may have been pulp hyperemia, which is reversible. It would be interesting to correlate these findings with histologic examination of the pulps. More often, teeth with previously damaged pulps having no clinical symptoms flare up as soon as orthodontic treatment is instituted.

Elongation is a simple and easy movement. The alveolar crest is lengthened by apposition of new bone. More often, new cemental lamellae are deposited on the root surface; less frequently new bony lamellae are built over the fundus of the socket, or a combination of both may occur, depending upon the amount of force used.

It is questionable from the available evidence whether depression of a tooth in its socket can occur, due primarily to the arrangement of the oblique fibers of the periodontal membrane. Some claims are made that it can be done; others believe that an illusion of depression occurs by the elevation of the proximating teeth, and others claim a group depression occurs. Cephalometric studies[8] so far have failed to enlighten us.

Rotation of the teeth is similar to a tipping movement, except in a horizontal plane. Tipping always complicates the process. The subepithelial connective tissues,[5] in failing to conform to the tooth movement may be a factor responsible for relapse. Clinically, relapses after rotation have occurred more frequently than after other types of tooth movement.

One basic feature of the attachment apparatus is that the periodontal membrane maintains a certain width.[14] This is why we always have resorption of bone of the pressure side of the socket. We would expect the periodontal membrane to follow the tooth on the tension side. However, this is not always true. Very often the cementum on the tension side becomes thicker, so there is not as great a movement of the periodontal membrane on this side. New cementum will be deposited on a root surface to prevent the periondontal fibers from becoming torn away, just as occurs in bone.

It was found that following the removal of a tooth in orthodontic procedure, a new and elongated transseptal fiber bundle was built.[17] In subsequent closure of the space, this fiber bundle became coiled when compressed, thereby

splitting and resorbing the bony crests. Crushing injuries of the periodontal membrane and some tooth resorption were also found. When the retaining appliances were removed, the contact points became abnormal. Contact points should be just as important in orthodontics as in operative dentistry.

In clinical practice we encounter two types of retained deciduous teeth[18]: those with successors and those without successors. Radiographs of retained deciduous teeth without successors reveal roots whose contours are irregular. The lamina dura of the surrounding bone cannot be clearly traced. Although these roots appear to be resorbed, they are extracted with difficulty, many times fracturing into several pieces. Histologic studies of these root fragments reveal fusion with alveolar bone.

In the normal shedding of deciduous teeth there are alternating stages of resorption and of repair: resorption of the deciduous root when the crown of the permanent tooth demands more room—the growth period—and repair of the deciduous root when growth of the permanent tooth ceases for a time—the rest period.

During the eruptive phase of the permanent tooth, both alveolar bone and deciduous tooth roots are resorbed to a larger extent than the actual movement of the permanent tooth would necessitate, and this excess resorption is repaired by a new formation of cementum and bone in the period of rest. During this repair phase a solid junction between bone and deciduous tooth can take place.

The attachment apparatus of the roots of deciduous teeth cannot accommodate the heavier stresses of an adult jaw; hence, in deciduous teeth without successors, resorption will occur due to stresses of occlusal trauma. After resorption a rest period will follow. The rest period is prolonged sometimes because of further eruption of the approximating teeth into an occlusal plane higher than that originally occupied by the deciduous tooth. So intense is this repair that fusion with alveolar bone follows.

In teeth with successors, the growth phase of the permanent tooth may be suppressed for longer than the normal period. In such cases the repair phase of the deciduous tooth may produce a complex type of structure that will be sufficient to block effectively the eruption of the successor.

Deciduous teeth with successors retained beyond the normal shedding time should be removed because of possible ankylosis. Submerged molars are always ankylosed. They become ankylosed after the repair stage has been initiated. Following ankylosis the proximating teeth continue to erupt, leaving the deciduous tooth behind, creating the illusion that it is disappearing from sight.

Extensive root resorption is sometimes a complication encountered during orthodontic treatment. The study made by Becks[19] has clarified our knowledge of the subject. He made a detailed study of one hundred patients having root resorptions. Fifty had been treated by orthodontists and fifty had no treatment. The prevalent disturbance was hypothyroidism, mostly below -20 B.M.R. Becks commented:

I am decidedly of the opinion that the root resorptions observed in orthodontic practice are produced not by mechanical force alone, but that they are

rather the result of an individual predisposition to increased resorptive activity, we might say, when a very "labile" osseous structure is found which in turn is due to various endogenous factors.

Carman's case[20] of extensive resorption is encouraging. His patient developed root resorption during treatment, and was found to suffer from hypothyroidism, hypocalcemia, and hypoglycemia. Orthodontic treatment was discontinued for a year during which time treatment of the systemic disturbances was instituted. Orthodontic treatment was resumed and there was no further root resorption.

The orthodontist should be concerned about the attachment apparatus from both a physiologic and a pathologic viewpoint. A knowledge of the many potentialities and of the remarkable adaptability of this apparatus will aid him in confronting his problems with a higher degree of efficiency. The orthodontist can obtain considerable valuable information from the pathologist to answer the ever-rising queries about what happens to the tissues when he works with them.

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FUNDAMENTALS OF ANCHORAGE, FORCE, AND MOVEMENT

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IT IS my assignment to discuss with you the fundamentals of anchorage, force, and movement. I was particularly cautioned not to make application to any specific technical procedure, but to confine my remarks to basic facts alone. This is as it should be, because fundamentals speak a universal language and are applicable to any technique one may use.

It is obvious in a discussion such as this that no formulas can be given which can be applied to every case under treatment. Nevertheless, an intelligent application of the fundamentals of anchorage, force, and movement can be a major factor in successful planning and treatment.

This entire subject must be approached through a comprehensive understanding of biology and related sciences. We owe a debt of gratitude to a host of research workers who have made invaluable contributions which have lifted our specialty from a state of empiricism to a scientific basis. It is from the works of these men that I have drawn my material for this presentation and to them I extend my thanks.

At this point it might be well to offer a definition as to just what we mean by fundamentals. According to J. B. Franklin,[1] "Fundamentals in general are primary foundations of principles supported by facts, truths, or axioms which are used as a guide to one's actions and thinking in arriving at a logical conclusion." Anchorage has too long been considered a mechanical entity to the exclusion of its biologic aspects, which in realtiy are its fundamentals. The two cannot be divorced entirely because mechanics in orthodontics is deeply rooted in biologic science.

Anchorage usually has been defined as "resistance to force" or "resistance to overcome an applied force." From a true mechanical concept, one could find little fault with such definitions, but since we are discussing fundamentals, we must view the subject from a biologic standpoint in conjunction with mechanics. Physical laws which operate on inanimate material behave quite differently when used on living tissue. It might better be stated that anchorage is resistance which is the result of the response of tissue change which may be favorable or unfavorable.

In the past we have limited our concept of anchorage too much to teeth alone. In reality, teeth are only the means which are to serve as units of resistance and as units to be moved because their crowns afford us opportunity of attachment. Their true significance lies in the fact that their roots are attached to bone by the fibers of the periodontal membrane. Bone, then, is the true source of anchorage because any force transmitted to teeth eventually is transmitted to bone through pull or push.

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We need not discuss growth of bone as a tissue, but I should like to mention two of its outstanding characteristics. The first is its ability of repair which is unlike enamel. The second, and one which is of interest to us particularly, is its ability to change to meet new demands placed upon it. This is well stated in the law of Wolff[2] which states, "Every change in the form and function of bone or in its function alone, is followed by changes in its internal architecture and no less definite alterations in its external architecture in accordance with mechanical laws."

The interpretation which some men placed on this law was the reason for the belief that increased function could bring about increased development. It was this erroneous conception which led us to believe that in Class II, Division 1 cases, when the teeth had been placed in their normal positions and normal function restored, bone would develop, thereby increasing the size of the mandible, which, of course, would be desirable in these cases, but which it never did. It may be noted in Wolff's law that no mention was made of the size, shape, or form of the mandible. The amount of bone in any individual mandible is of genetic origin. Only its structure can change. Of all the tissues in the body, bone is most dynamic. It is continually breaking down and rebuilding throughout life.

This ability to change and meet new demands was climaxed in the experimental work of Oppenheim. He made a direct application of the change of bone to orthodontics. Prior to the histologic studies of Oppenheim, two theories had been advanced. The first was based on the assumption that alveolar bone is resorbed and eliminated by osteoclasts on the side of pressure, while new bone is built on the side of pull. The other theory was that of the compression and elasticity of the alveolar bone. The first scientific report of these changes was made by Sandstedt in 1904.

In 1911, Oppenheim reported his findings.[3] He placed appliances on monkeys, using the Angle expansion arch. The findings were based after the appliances had been active for forty, thirty-five, fifteen, and five days, respectively. He found that there was reorganization of bone extending from the gingival margin two-thirds of the distance to the root apex. The animals he worked on had their deciduous teeth, and he claimed there was no movement of the apex opposite to the movement of the crowns. If resorption was taking place at the apices of these teeth, this claim lost some of its validity. Regardless of this, the true significance of this work was that of reorganization of bone.

Oppenheim's microscopic slides were made from the tissues immediately surrounding the teeth which had been moved. Marked changes showed on the wall of the alveolus. This was attacked by osteoclasts on the pressure side with hollowed-out spaces on the alveolar wall so characteristic of these cells, and by osteoblasts on the outer wall of the alveolus. Then there appeared a type of transformation from calcified to a sort of cartilaginous state which he called osteoid tissue. Its state corresponds to our predentine in a tooth. The bony spicules which appeared were oriental parallel to the direction of the force on both the labial and lingual sides. On the side of tension, osteoblasts were pres-

ent at the alveolar wall and osteoclasts were on the outer surface of the alveolar bone. In fact, the architecture of the bone had changed from one that was designed to withstand the forces of mastication to one that was withstanding orthodontic forces. In other words, here was an application of Wolff's law.

Today we know that even the placing of temporary stopping in a cavity or of separating wire between teeth causes changes in the structure of bone around these teeth. When Oppenheim used excessive forces on the teeth of monkeys, he found the blood vessels engorged, the presence of thrombi, and necrotic changes taking place. He also found that where the force was so great that tearing of the periodontal membrane occurred on the tension side, the symptoms of pressure appeared on the opposite side of the tooth. A fulcrum is thereby set up in the gingival area which usually results in the root apex moving in the opposite direction in which the force is directed. From the work of Oppenheim we can come to this conclusion: True anchorage is not available in the mouth. As stated before, teeth in themselves do not constitute anchorage. They are merely our means of attachment and serve us through their attachment of the periodontal membrane to bone, which is our true source of anchorage.

I previously referred to what Oppenheim called osteoid tissue. Naturally, this tissue is very much less resistant than true bone. It is only a state through which bone passes on its way to becoming true calcified bone. This being true, we are forced to another conclusion, and that is that anchorage cannot be prepared and be effective. It is still true that the undisturbed tooth affords the best anchorage.[4] The axial inclination of teeth can be orientated to resemble stakes driven into the ground to which guy ropes are fastened, but, as I mentioned before, the results of physical laws do not operate the same when applied to living tissue.

Since bone is so quick to respond, and since teeth are the only source of appliance attachment, would it not seem reasonable to use all the dental units which are available so that we might obtain all the anchorage possible in the treatment of any case? The more teeth we use, the more periodontal fibers do we have attached to bone which in the last analysis means more resistance.

A tooth is suspended in its socket by the fibers of the periodontal membrane. These fibers are nonelastic and run in curved lines. Any force on a tooth is resisted first of all by the compression of blood and lymph vessels in the socket and second by the fibers of the periodontal membrane. It then follows that the greater the surface area which the root affords, the greater will be the available resistance. This would lead us to a discussion of root design of the entire denture which I feel would be too time consuming.

Having discussed the source of anchorage, let us now consider the manner of its use. What are the mechanical attachments to be which in turn will determine whether we have simple or so-called stationary anchorage? Whenever we use attachments to teeth which are to serve as anchorage, if the attachment allows the tooth to tip or rotate on an axis, if the resistance is overcome, this is called simple anchorage. The round labial arch appliance is an example.

If the attachment used is a rectangular tube or a square or half round tube with a like wire to fit it, if resistance is overcome, the teeth will tend to move in a more bodily movement. This is termed so-called stationary anchorage, which in truth is a misnomer.

This leads us to an analysis of these two types of anchorage. In simple anchorage,[5] with an attachment such as just described, the resistance is applied to the group of periodontal fibers near the crest of the alveolus where fibers are the most numerous. Using a gentle force, this leads to a change in the bony architecture at this point of the alveolar process with the fulcrum somewhere near the middle third of the root. Upon continued application, bony changes progress until the apex is reached, when the entire bony socket is transformed into osteoid bone, which, as I said earlier, is a much less resistant tissue.

In so-called stationary[5] anchorage, the attachment is such that the resistance enlists all the fibers of the periodontal membrane from the crest to the apex on the side of pull. Because of the greater number of fibers involved, resistance is increased. The same bone changes take place as in simple anchorage, but, owing to the greater number of fibers employed and because of the larger surface area to which they are attached, the immediate progress is more slow. Since bone reaction, followed by the formation of osteoid tissue, is present in both simple and stationary anchorage, it follows that the real difference between the two is the difference in the time element of tissue reaction.

From this analysis it seems logical that so-called stationary anchorage would be the most desirable type to use, especially when we attempt to change arch relation as we do in Class II or Class III cases. Here we use a type of anchorage known to all of you as intermaxillary anchorage which can be either simple or stationary depending on the attachments used and the wires to fit them. By means of intermaxillary elastics, the lower arch is pitted against the upper arch, making the action reciprocal. In other words, there is an equal amount of forward pull on the lower arch and a like amount of backward pull on the upper arch in a Class II case. It is the fulfillment of the old law of physics that to every action there is an equal and opposite reaction.

There are two methods of utilizing the anchorage of the lower arch in practice today. The first and probably the most commonly used is the lingual arch appliance with the arch either soldered to the molar bands or secured through some removable attachment with the arch wire resting on the lingual surfaces of the lower anterior teeth. When using elastics in the correction of a Class II case, the pull on the first molars is upward and forward, and it would seem to me that all the anchorage available is not being utilized. The anterior section of the wire is not stable by virture of the fact that it does not rest on a flat plane, but rests on an inclined plane which allows these teeth to tip labially. Another factor to consider is the length of time the elastics must be worn. If the lingual arch were further stabilized in the anterior segment, anchorage would be increased.

The second method used is the banding of all the teeth as embodied in the edgewise arch appliance. One objection to this method is that in order to band

all the teeth, a certain amount of space must be added to the arch which in turn causes tissue changes around each tooth. This violates the principle established earlier that the undisturbed tooth is the best source of anchorage. Despite this criticism, I believe that since we are enlisting such great numbers of periodontal membrane fibers, and since we have control of each tooth in three planes of space and have the use of torque force, it affords the maximum amount of anchorage available in the mouth. There are other factors such as the deep overbite, tooth design, and musculature which must be considered in securing the maximum amount of anchorage within the oral cavity. These are important adjuncts to anchorage, and while they cannot be overlooked they are largely dependent on other factors which make it impossible to establish fundamentals regarding their use. To this choice of anchorage can be added another which is outside the mouth, commonly known as occipital or extraoral anchorage.

This type is one of the oldest sources ever used and conforms to our true meaning of anchorage as far as stability is concerned. Its most serious drawbacks are esthetics and comfort to the patient. The latter in great measure has been overcome through the use of better mechanics. It can be manipulated to exert gentle intermittent force with the cooperation of the patient. Today its use is increasing not only as an auxiliary source of anchorage, but also for treatment of certain types of cases of malocclusion as well.

The second part of this assignment which has to do with the fundamentals of force and movement does not lend itself as well to the establishment of fundamental principles such as we were able to recognize in our discussion of anchorage.

This is true first of all because of the nature of the problem. We are applying forces to teeth which in turn are transmitted through the fibers of the periodontal membrane to bone. We cannot control the reaction of tissue to any force. So far, there is no general routine whereby the amount of force or the extent of movement within certain time limits can be applied to all cases. Each treatment is an individual problem.

Secondly, experimental work up to this time has not been able to establish a unit of force which is truly measurable, such as a calorie representing a unit of heat or an ohm signifying a unit of resistance. Damage to tissues is demonstrable only by microscopic examination. When we think of the way in which Nature exerts forces on the denture, we find that muscular forces are not only intermittent, but that force is applied for very short periods of time with comparatively long intermissions.[6] Some of these forces are considerable but last no more than a few seconds. In the healing process of bone, we find Nature healing a fracture in young individuals in from four to eight weeks' time, depending on the type and extent of injury and the viability of tissue.

Since Nature is so variable, how can we expect to construct appliances capable of imitating Nature? Here again we must turn to the research worker whose findings must guide us as to what to do and what not to do. Even here we find no unanimity of opinion. Some claim that when force is applied to a tooth, the movement can be biologic. Others claim the opposite. To me, the

outstanding work in this field has been done by Oppenheim. He has done not only extensive research on animals, but also in 1934 published the results of his work on human beings. In this latter work he moved the upper first premolar teeth of patients in whom he intended to extract as part of the therapy. He used different appliances with varying types of tooth movement and with varying degrees of force.

Oppenheim[7] concluded that all experimental work done on animals could not be verified when transferred to human material because of differences in tissue reaction and functional differences in their dentures. Oppenheim further states, "No type of force transmitted to a tooth can be biologic." In other words, injury is always inflicted through appliance manipulation. Since injury to tissue is unavoidable just as it is in surgery, the important thing is to minimize its degree. We previously stated that bone possesses the inherent ability of repair, provided the injury is not too great. The problem really confronting us then is to do as little injury as possible with sufficient time between visits for repair.

What we constantly must have in mind is that the periodontal membrane, insignificant as it may seem, is of the utmost importance to the orthodontist. This membrane, which is only a fraction of a millimeter in thickness, together with the inherent force of growth, is responsible for the tissue changes which take place. Skillen[8] says, "There is only one controlling structure, one dictator, and this is the periodontal membrane."

Oppenheim[7] further states:

> Since we are quite in the dark as to whether an individual has a high tissue resistance or is very susceptible to tissue damage, I consider it unjustified and wrong to use indiscriminately the same measured amount of force for all persons even disregarding their ages. I repeat again, we have only one reliable clinical criterion for the correctness of the forces applied in any given individual; i.e., the firmness and non-sensitiveness of the teeth. The patient should not be forced to alter his diet during treatment nor avoid normal hard food because of soreness of his teeth. Looseness in most instances is the clinical sign of some lost bony or ligamentous support, or both. Sensitiveness and soreness are the subjective symptoms of present or recent inflammation, hemorrhage or destruction.

Oppenheim found that with gentle intermittent forces, no deviation of the apex in the opposite direction to the crown movement was found in the first eight weeks. If the movement exceeded eight weeks, the deviation of the apex was microscopically noticeable.

In the treatment of canines in infralabioversion, impacted and surgically freed canines which are usually moved to the line of occlusion through the force of traction, either by spring force or ligature or coil spring, Oppenheim[7] claims that the death of the pulp has usually occurred. After the space has been acquired for the canine, he advises a space maintainer leaving to Nature the alignment of the canine assisted by lip exercises. His contention is that the continuous action of spring force, no matter how gentle, is much too strong and must strangulate the vessels entering the apex in the extrusive movement of teeth. He says, "Impatience to attain success is the principal cause of our failures."[7]

In a series of experiments on dogs, Schwarz approached the problem of determining the relationship between an orthodontic force which he had measured and the tissue changes produced by this force. Schwarz[9] stated:

> Only where the force applied had not exceeded twenty grams pressure per square centimeter of root surface (this he claims is the capillary blood pressure), was the desired ideal biological tissue reaction observed; namely, uniform bone resorption on the side of pressure and corresponding uniform apposition of new bone on the side of pull without any evidence of injury to the periodontal tissues or of root resorption. When approximately sixty grams had been applied for several weeks, the periodontal membrane was compressed and crushed between root surface and bone, so that no orthodontic bone resorption could take place. Instead, undermining bone resorption was found at the borders of the damaged areas and there was evidence of root resorption in addition to the traumatic injury to the periodontal membrane.

Schwarz does not tell us how we can arrive at these measurements in the human tooth; therefore his findings do not lend themselves to a practical application of force.

Both Schwarz[9] and Stuteville[10] disagree with Oppenheim and say that orthodontic tooth movement can be biologic. The application of any force in treatment demands the highest respect for tissues and a generous amount of good judgment. I believe most of us are guilty of using excessive force, too strong elastics, and too much treatment without periods of intermission for repair to take place. As Oppenheim shows, the damage is not only to alveolar bone but extends to periodontal membrane, cementum, and pulp as well. Another factor which should command attention is the distance through which force travels. In other words, the greater the range, the gentler the fore and, conversely, the shorter the range, the greater the force.

When it comes to force and movement of teeth, we are still in the empirical stage. We are not effecting some of the movements of teeth we thought we were, and we are inflicting injury to tissue of which we are unaware. This whole problem is honeycombed with factors which as yet we do not understand. For example, what definition could be given to describe a gentle force[11]? A weak force in my hands may be a strong force in yours, and vice versa. We speak of intermittent and continuous forces and yet we know that teeth continue to move long after the force of the appliance is spent. To add to these perplexities, we have the variation in tissue reaction of different individuals.

Much more research must be done experimentally on human beings regarding tissue changes, and much more cephalometric x-ray appraisal has to be recorded to show what we do and what we do not accomplish. Until more evidence is forthcoming, the orthodontist must be content with exercising that "something" which, for a better term, we may designate as "tissue feel" or orthodontic sense.

In summarizing, I should like to emphasize the following:

1. "Fundamentals in general are the primary foundations of principles supported by facts, truths or axioms which are used as guides to one's action and thinking in arriving at a logical conclusion."

2. Anchorage is resistance which is the result of the response of tissue changes which may be favorable or unfavorable.

3. Teeth in themselves do not constitute anchorage.

4. The real source of anchorage is the biologic response of bone.

5. The periodontal membrane is the connecting link between teeth and bone.

6. The greater the number of periodontal fibers employed, the greater the resistance.

7. True anchorage is not available in the oral cavity.

8. The undisturbed tooth is the best unit of resistance.

9. Anchorage cannot be prepared and be effective.

10. Simple and stationary anchorage differ only in their time of tissue reaction.

11. Stationary anchorage offers the most resistance because it employs the most periodontal fibers.

12. Occipital or extraoral anchorage conforms to our true meaning of anchorage as far as stability is concerned.

13. Viability of tissue is of prime importance.

14. Gentle intermittent forces are best with plenty of time for repair.

15. All tooth movements cause injury to tissue.

16. Forces, no matter how gentle, are almost always excessive.

17. Tipping movements predominate.

18. The greater the range of the force applied, the gentler the force; and, conversely, the shorter the range, the greater the force.

19. Fundamentals cannot be established in the applications of force and movement, as we are still in the empirical stage.

20. Each treatment requires individual judgment.

21. Soreness and looseness of teeth are the best subjective symptoms for the correctness of the forces applied.

22. "Impatience is the cause of many failures."

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Reports

REPORT OF THE SECRETARY

The report of the Secretary covers the period from Sept. 30, 1946, to April 23, 1948.

During that time, 134 persons were elected to membership. Eleven active members, one honorary member, and one retired member were lost by death.

The active membership as of this date is as follows:

Active members, Sept. 30, 1946		797	
New members, Sept. 30, 1946, to April 23, 1948		134	80—1947; 54—1948
Reinstated member		1	
Total		932	
Active members deceased	11		
Active members retired	9		
Active members resigned	9		
		29	
Total active membership		903	
Honorary members	10		
Affiliated members	11		
Army members	5		
Retired members	6		
		32	
Total members of all classes		935	

New members were distributed as follows:

Central Section	9
Great Lakes Society	34
Northeastern Society	47
Pacific Coast Society	22
Rocky Mountain Society	1
Southern Society	8
Southwestern Society	13
	134

Active membership is distributed as follows:

Independent members	16
Central Section	125
Great Lakes Society	119
Northeastern Society	272
Pacific Coast Society	171
Rocky Mountain Society	19
Southern Society	88
Southwestern Society	93
	903

Respectfully submitted,
MAX E. ERNST, Secretary.

Read at the Forty-fourth Annual Meeting of the American Association of Orthodontists, Columbus, Ohio, April 26-29, 1948.

REPORT OF THE NOMENCLATURE COMMITTEE OF THE AMERICAN ASSOCIATION OF ORTHODONTISTS

At the Forty-third Annual Meeting of this Association held in Colorado Springs in September of 1946, this Committee submitted a list of forty-six terms which we felt would aid in developing a better language for our specialty. While they met with the unanimous approval of the Committee, we did not request that they be adopted as the official nomenclature of the American Association of Orthodontists, but rather that they be submitted to the membership for appraisal and study. We wish to follow the same policy this year, although a considerable number of new terms have been added and some of the definitions of older ones have been altered in an attempt at clarity. The old terms with their definitions as well as the new ones will be found appended to this report.

In our effort to gain as much information as possible upon this subject and especially to get a cross section of opinion, we have reviewed the Report of the Nomenclature Committee of the British Society for the Study of Orthodontics. This was sent to us by Dr. Harold Chapman, one of our members in London, because of his interest in our problem. Since it was adopted more than twenty years ago and the orthodontic concept especially in the United States has undergone many changes during the past two decades, we found little in it which we felt would apply today. It served a useful purpose, however, in bringing to our attention present-day trends and terms necessary to make them clear and understandable.

The new terms we are submitting for study have their background in part in the field of anthropology, such as prognathic and orthognathic. We likewise feel that we can profit from cephalometrics and especially its combination with roentgenology as illustrated by the work done by Broadbent and Todd in the Bolton study and research now being carried out by Wylie at the University of California. Certainly if our literature is to be made thoroughly understandable, we need such terms as the Bolton nasion-plane, the Frankfort plane, the orbitalia, the tragion, the gonion, and the gnathion to describe and identify certain anatomic and craniometric landmarks. Dr. Wylie has added one more which is highly descriptive, dysplasia. This literally means badly put together, and while heretofore it has been used to describe such conditions as cleft palate and harelip, there is no logical reason why it will not apply equally well to any of the dysgnathic anomalies which the orthodontist must appraise. In discussing this new term, Dr. Wylie states: "I define dysplasia as disharmony between component parts. We know the following kinds of dysplasia with which we deal in the field of orthodontics: dental dysplasia, i.e., 'peg' laterals and other anomalous teeth; dentofacial dysplasia, between teeth and bones of the face, i.e., crowding or spacing; maxillomandibular dysplasia, between one jaw and the other; craniofacial dysplasia, between cranium and the face. While these dysplasias exist as described above, I feel that the best method of describing and measuring them is in terms of three planes of space: anteroposterior dysplasia, vertical dysplasia, and lateral dysplasia." We venture the opinion that in years to come those who follow the research conducted with the aid of the roentgenographic cephalometer will encounter these terms with increasing frequency.

In our efforts to aid in developing an adequate orthodontic terminology, we have sought to avoid any conflict with the nomenclature of dentistry. As a matter of fact, we are hopeful that what is eventually developed by our specialty will be supplementary and fulfill the definite requirements of our specialty.

In our efforts to minimize controversy and achieve scientific accuracy, we gained permission from this Association to employ a language authority to review our terms and act as a consultant and referee. After careful deliberation we selected Hereward T. Price, Ph.D., Professor of English at the University of Michigan. He was a member of the Oxford Dictionary Staff at Oxford University from 1896 to 1904 and a member of the Middle English Dictionary Staff at the University of Michigan from 1929 to 1946. He has been Professor of English from 1929 to the present time. From this brief but incomplete account of his accomplishments it can readily be seen that he is in a position from the standpoint of language to give us the help we need.

Read at the Forty-fourth Annual Meeting of the American Association of Orthodontists, Columbus, Ohio, April 26-29, 1948.

Dr. Price was contacted by a member of our Committee, Dr. George R. Moore, early in 1947, and he expressed the willingness to collaborate with us in our task. All material has been submitted to him and his verdict follows: "I have carefully inspected all the material dispatched to me as I have received it and I have found that the choice of vocabulary was uniformly excellent. For this reason I have not interfered or made any communication, as there did not seem to be anything that I could usefully say. There is, however, one letter with regard to which an observation might be of use—that of 17 July, 1947, in which criticism is made of eugnathic, dysgnathic anomaly. So far as a layman can understand the situation, this phraseology appears to me to be absolutely correct. It states the fact, the anomaly occurs in a eugnathic or a dysgnathic jaw, respectively. Too much criticism of vocabulary is directed toward forming a symmetrical pattern of thought. Words exist, however, to express facts, and if a word expresses the fact, it has done all that can be expected of it."

As a committee we wish to express our appreciation to Dr. Harold Chapman of London, to Dr. Wendell L. Wylie of San Francisco and to Dr. Hereward T. Price for their interest and collaboration.

Respectfully submitted,
KYRLE W. PREIS,
GEORGE R. MOORE,
JAMES D. McCOY, Chairman.

A LIST OF TERMS APPROVED BY THE NOMENCLATURE COMMITTEE AND RECOMMENDED FOR APPRAISAL AND STUDY BY THE MEMBERS OF THE AMERICAN ASSOCIATION OF ORTHODONTISTS

1. *Orthodontics* (n.)
   The science which has for its object the prevention and correction of dental and oral anomalies.
2. *Orthodontic* (adj.)
   Describing or referring to orthodontics.
3. *Orthodontically* (adv.)
   Implying manner of action.
4. *Anomalies*
   Aberrations or deviations from normal anatomical growth, development, or function.
5. *Dental anomalies*
   Those where a tooth or teeth have deviated from the normal in form, function, or position.
6. *Oral anomalies*
   Those which include other oral structures in addition to the teeth.
7. *Eugnathic anomalies*
   Those limited to the teeth and their immediate alveolar supports.
8. *Dysgnathic anomalies*
   Those which extend beyond the teeth and include the maxilla, the mandible, or both.
9. *Dentofacial anomalies.*
   Terms indicating oral and dysgnathic anomalies.
10. *Macrognathia*
    Indicating a definite overgrowth of the maxilla and mandible.
11. *Macrognathic* (adj.)
    Descriptive of macrognathia (patient is macrognathic).
12. *Micrognathia*
    Indicating a definite lack of normal development of the maxilla and the mandible.
13. *Micrognathic*
    Descriptive of micrognathia (patient is micrognathic).
14. *Macroglossia*
    A definite overgrowth of the tongue.
15. *Macroglossic*
    Descriptive of macroglossia (patient is macroglossic).

16. *Microglossia*
An abnormally small tongue.
17. *Microglossic*
Descriptive of microglossia (patient is microglossic).
18. *Myofunction*
Normal muscle function.
Myodysfunction
Imbalance or disturbance of muscle function.
19. *Normal relationships*
Malrelationships
Terms applied to conjoining structures as they should be or with this relationship disturbed or disrupted.
20. *Normal dental function*
Dental malfunction
Terms to indicate the correct or incorrect action of opposing teeth in the process of mastication, incorrectly referred to as "normal occlusion" and "malocclusion."
21. *Normal occlusion of the teeth and*
Malocclusion of the teeth
Terms indicating the relations of the opposing dentures when brought into habitual opposition.
22. *Anterior*
Forward position.
23. *Posterior*
Situated behind.
24. *Unilateral*
One side.
25. *Bilateral*
Both sides.
26. *Maxillary*
Referring to the maxilla.
27. *Bimaxillary*
Maxilla and mandible.
28. *Mandibular*
Referring to the mandible.
29. *Symmetrical*
Evenly balanced or uniformly developed.
30. *Asymmetrical*
Unevenly arranged, or out of balance.
31. *Contraction*
Indicating teeth or other maxillary and mandibular structures nearer than normal to the median plane.
32. *Distraction*
Indicating teeth or other maxillary and mandibular structures farther than normal from the median plane.
33. *Protraction*
Indicating teeth or other maxillary or mandibular structures anterior to their normal position.
34. *Retraction*
Indicating teeth or other maxillary or mandibular structures posterior to their normal position.
35. *Attraction*
Indicating teeth or other maxillary or mandibular structures which are superior (elevated) to their normal position.
36. *Abstraction*
Indicating teeth or other maxillary and mandibular structures which are inferior (below) to their normal position.

37. *Intraversion*

Extraversion

Terms to indicate teeth or other maxillary structures which are too near or too far from the median plane.

38. *Anteversion*

Retroversion

Terms to indicate teeth or other maxillary and mandibular structures too far forward (anterior) or too far backward (posterior) from the normal or generally accepted standard.

39. *Supraversion*

A term to indicate teeth or other maxillary structures above or below their normal vertical relationships.

Infraversion

A term to indicate teeth which have failed to erupt to the usual occlusal plane.

40. *Linguoversion*

A term indicating any deviation from the normal line of occlusion toward the tongue.

41. *Torsiversion*

Indicating an axially rotated tooth.

42. *Mesioversion*

When applied to a tooth, indicates that it is closer than normal to the median plane or midline. When applied to the maxilla or mandible, means that it is anterior to its normal position.

43. *Distoversion*

When applied to a tooth indicates that it is farther than normal from the median plane or midline. When applied to the maxilla or mandible, means that it is posterior to its normal position.

44. *Prognathic*

Having jaws projecting beyond the upper part of the face.

45. *Orthognathic*

Having straight jaws; not having the lower parts of the face projecting.

46. *Bolton-nasion plane*

A plane passing through the upper face and lower cranium. Its anterior termination is at the junction of the frontal and nasal bones in the midplane. The posterior termination is the highest point in the profile of the notches at the posterior end of the condyles on the occipital bone.

47. *Frankfort plane*

A horizontal plane through the face and cranium. It passes through the two orbitalia and the two tragia.

48. *Gnathion*

The lower end of the symphysis of the mandible.

49. *Orbitalia*

Located on the lower edge of the orbit just below the pupil.

50. *Tragion*

Located on each side at the upper end of the tragus.

51. *Gonion*

The mandibular angle point.

52. *Roentgenographic cephalometer*

An apparatus for making orthodiagraphic roentgenograms of both profile and frontal views of the face and cranium.

53. *Dysplasia*

This term literally means badly put together and may be defined as disharmony between component parts. In the field of orthodontics we may have ". . . dental dysplasia, i.e., 'peg' laterals and other anomalous teeth; dentofacial dysplasia, between teeth and bones of the face, i.e., crowding or spacing; maxillomandibular dysplasia, between one jaw and the other; craniofacial dysplasia, between cranium and the face."

Department of Orthodontic Abstracts and Reviews

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The Clinical Basis for Bone Healing: By Stephen S. Hudack, M.D., *J. Periodontol.* **19**: 7-10, January, 1948.

Evidence that local circulatory supply is important is shown by the peculiarities of behavior of fractures which are in contiguous regions but which behave differently depending upon the adequacy of the local arterial supply. Intracapsular fractures heal slowly and with difficulty. With pinning, the healing period is a minimum of six months. Even when healed, because of the delicate balance of the circulatory supply, there may be a late necrosis of the head. This may come on two and one-half years after the fracture has healed. Intertrochanteric fractures, on the other hand, can hardly be kept from healing. These heal within two months and scarcely ever affect the nutrition of the femoral head.

Colles' fracture of the wrist heals invariably, while the fractures of the scaphoid are a constant source of difficulty for the surgeon; and non- or delayed union is common. The fractures of the anatomical neck of the humerus as compared with the fractures of the surgical neck are peculiar in this sense. In the anatomical neck fractures, all circulation is destroyed. In surgical neck fractures, less than an inch away in the same bone, union with good function results with proper treatment. Where the circulation has been destroyed, the head fragment virtually becames a sequestrum and unless removed can lay the basis for a degenerative arthritis.

If you have a fracture of the coronoid process, it heals almost invariably. If the fracture is in or near the capsule, you may be headed for trouble. You may better anticipate it and excise the temporomandibular joint.

Clinically, we know that the grafts are much more likely to take if they are placed laterally where the muscle beds form a source of revascularization.

Microscopically, in experimental fracture healing, an infinite variety of discrepancies in bone formation may be seen. These microscopic variabilities have been described by Sicher, Urist, and a host of other authors too numerous to cite here.

Whether you explain bone deposition by a cellular, biochemical, or vitalistic concept, the fact remains that somewhere in there blood vessels are a factor, and without microscopic blood supply bone does not form. Because of the conflicting mass of evidence which has accumulated now for decades, and which has been so ably set down by Sicher and his colleagues, I have begun to seek in still another direction—in the differentiation of the protein matrix.

Probably nowhere in the skeletal system is accurate reduction more important than in fractures of the mandible and maxilla. There is necessity for good reduction in the weight-bearing lower extremities to preserve axis length and rotation. But for the preservation of function, the balance of forces is not so delicate as in the jaws.

But nowhere is accurate reduction more important than in maxillomandibular injuries. I am speaking now of good dental surgery where the surgeon expects to preserve the teeth with good occlusion and not simply to preserve the jaw for a prosthesis. I have not seen a twenty-year follow-up on jaw fractures, but even a six-month follow-up has convinced me that reduction without good occlusion is poor dental surgery and a twenty-year follow-up should prove this contention. It is true that there is a certain latitude in mandibular reductions. But this is in terms of millimeters where grinding and adaptation allow for some correction. But perfect reduction with perfect occlusion is still good dental surgery.

There have been certain biochemical factors which have been stressed by Murray and his associates, hydrogen-ion concentration, for example. The early observations of pH change made by myself and Dr. Clay Ray Murray were done with quinhydrone electrodes with faulty shielding of the animals and leads. Extremes of 4.6 and 8.3 observed with this technique using a balanced Wheatstone bridge were almost certainly faulty due to the crudity of equipment available in those days. However, more recent observation with a more careful technique and proper shielding still reveals a shift of tissue pH following injury. One to three days after soft tissue injury not involving fracture, the hydrogen-ion concentration is in the range of 6.9 and 7.1; by ten days, the shift is toward the alkaline side, and observations of 7.6 and 7.9 have been made. This again is in soft tissue injury, not in the presence of fracture. These variations of pH may be greater in the presence of fracture. But such redeterminations with improved technique as may be necessary to prove the point have not as yet been done.

I make these comments because of the importance of hydrogen-ion concentration in the effectiveness of alkaline phosphatase. It is considered by most observers that for optimum effect on the natural substrate, a pH range approaching 8.3 is necessary. Needless to say that the alkaline shift is not attained unless good fixation is present and tissue destruction by motion or infection is absent. These facts would be of academic interest only if it were not that clinical behavior of fractures hinges on them.

We know from clinical experience that compound fractures properly débrided, reduced, and fixed early do not go on to infection and form very little callus. It must be equally true that early reduction and immobilization of mandibular fractures cut down the incidence of osteomyelitis and sequestrum formation. Fortunately, unlike many other bones in the body, the maxilla and mandible, except for articular condyles, are in a rich vascular bed. For this reason, it is my belief that if compound fractures of the jaws were seen and treated early, infections could be eliminated. Exception to this is in the cases where the fracture line happens to cross the root bed of a tooth and it is not removed. These, I believe, act as sequestra and form the basis for foci of infection. In other words, without their removal, débridement is not complete. How many times out of ten thousand extractions does one get infection? Yet, an extraction is a compound injury where immobilization is not required.

Phrasing it in another way, because of the vascularity of the maxillomandibular beds, development of osteomyelitis following compound fracture presupposes either an error in treatment on the part of the dental surgeon or an accident in time, where the patient was not available soon enough; or, of course, massive destruction of soft tissue with injury to the vascular bed.

In other bones of the body, the surgeon is not so fortunate. In parts other than the jaws, excessive reactions of vascular spasm or vascular injury introduce problems of Sudeck's atrophy, sterile sequestration, and delayed union or nonunion, and a host of other problems which do not plague the periodontist.

I believe that the mandible and maxilla are special bones with specialized function, and conclusions or generalization on the basis of experience with other bones of the body would not be valid and perhaps not pertinent.

Thumb-Sucking. Any Questions? *Brit. M. J.*, Sept. 13, 1947, pp. 439-440.

Q.—A male child, aged 4½ years, has been thumb-sucking since the age of 18 months. All the known remedies have been tried without effect, including admonition but not punishment. The child will hide in order to carry out the habit without being seen. Lately the act has been made worse by the inclusion of the forefinger of the same hand stuck into the nostril. The upper incisors are being pulled forward and the child is tending to lisp. What remedy can you suggest?

A.—To be effective, the remedy must be based on the cause. The late onset of the habit, at 18 months, suggests that at this age there was some emotional disturbance that made this child turn to thumb-sucking for comfort; that he finds relief in this way is clear from the urgency that now drives him to hide in order to carry it out. Usually the sucking of thumb or fingers represents a compensation for real or fancied loss of maternal love; it may well arise on account of a temporary separation between mother and child, or through some physical or environmental stress that the child cannot understand. In these cases it may be necessary to disregard the habit for a while, and to concentrate on supplying the need that has induced it, at the same time providing additional outlets in play or other acceptable activities, with all possible warmth of parental comfort. If home measures fail, the trouble is likely to be resolved without long treatment by psychiatric advice and child psychotherapy, unless there are special complications.

Molding and Casting: For Moulage Workers, Sculptors, Artists, Physicians, Dentists, Criminologists, Craftsmen, Pattern Makers, and Architectural Modelers: By Carl Dame Clarke, Ph.D., Associate Professor of Art as Applied to Medicine, School of Medicine, University of Maryland. Illustrated. pp. xiii+304. Baltimore, The Standard Arts Press, 1947.

Clarke is well known for his contributions to medical art. To the dentist, the art of molding and casting is of especial interest. This work goes much farther than books on this subject intended primarily for dentists. Plaster may be mixed in rubber, glass, or enamel bowls and need not be confined simply to the use of rubber bowls. The use of aerosol is advised as a wetting agent to prevent the formation of air bubbles. The material is applied with a brush or spray gun to the pattern before the plaster is poured. It is interesting to note that Clarke uses a different terminology than that generally employed in dentistry. For example, he speaks about prosthetic patterns from which molds are made in plaster and from which, in turn, casts are made. At other times, he refers to the taking of impressions as such and further seems to use the words mold and cast interchangeably. It should not be too difficult, however, for the dentist to discern the actual meaning implied by the author.

Molding and Casting.—Facial masks are discussed and illustrated. The use of agar for this purpose is described. One of the best separators, we are informed, is one part by weight of beeswax to nine parts of carbon tetrachloride, a mixture which can be easily made in the office. Throughout, the formulas for pattern making, molding, and casting materials are described, and commercial dealers where these products may be obtained are listed. Moulages of facial and body prosthesis are discussed.

This volume will be found of interest and practical use by dentists and especially by orthodontists, whether for the purpose of making facial casts as part of their records or as a hobby.

What People Are: A Study of Normal Young Men: By Clark W. Heath. In collaboration with Lucien Brouha, Lewis W. Gregory, Carl C. Seltzer, Frederic L. Wells, and William L. Woods, The Grant Study, Department of Hygiene, Harvard University. Pp. xii+141. Price, $2.00. Cambridge, Mass., Harvard University Press, 1946.

This is one of the studies of normal human beings supported by the Grant Foundation. The subjects dealt with are students at Harvard, and the plan is to follow the careers of participants in the study for fifteen or twenty years or more. The assertion is expressed that all or nearly all of the young people of the country need aid that will direct them to their places in the world to which their respective inherent levels of achievement entitle them. Normal in this study is defined as the balanced, harmonious blending of functions that produce good integration. Such integration is reflected in widely divergent types of personality and behavior. Normal as described in this book does not mean perfect nor does it mean a statistically average person. Strictly speaking, none of the young men described in this study are free from abnormalities—all have some defects. To be otherwise, we are told, would in itself be abnormal. A new term for normal has been suggested by C. Dailey King who uses the word "paradic," meaning, "that which functions in accordance with its inherent design."

Of the 265 young men examined, there was not one who could be considered normal in a strictly medical sense. The medically perfect person does not exist. Even in the matter of body temperatures it was found that not more than 18 per cent showed the average temperature of 98.6°. A considerable amount of defects with respect to the teeth was found. Some crowding or spacing of the teeth was found in 57 per cent of the group. Minor malocclusions were common, and 44 per cent had fillings in nine or more teeth. Only 4.5 per cent had no fillings or cavities present in their teeth. A study of the social or economic data shows that sound or successful young men emerge as often from homes broken by death of parents, separation, or divorce as from intact homes and those in which family relationships are happy.

The 1947 Year Book of Dentistry: Edited by Lester Cahn, D.D.S.; George W. Wilson, D.D.S.; Carl W. Waldron, M.D., D.D.S.; Stanley D. Tylman, D.D.S., M.S.; George R. Moore, D.D.S., M.S. Consulting editor, Howard C. Miller, D.D.S., LL.D. Illustrated. Pp., 704. Price, $3.75. Chicago, The Year Book Publishers, Inc., 1948.

In keeping with the drive on the control of cancer *The Year Book* publishes an article by Dr. Lester R. Cahn who edits the section on "Oral Pathology and Oral Medicine." The author expresses the opinion that the dentist should have as complete a knowledge of the pathology and pathogenesis of cancer as any surgeon in order that he may be able to recognize the disease early and perhaps also to prevent the factors which can cause cancer. Diseases of the mucosa, including the gingiva, are reviewed.

An article by Sharp and Spickerman of California, based on eighty-one cases of cancer of the tongue, twenty-seven of whom were seen in private practice, indicates that excessive smoking was a factor in one-third of the patients. Other etiologic factors were jagged, broken, or rough teeth, ill-fitting plates or plate material containing chemical irritants or tonsillitis of long standing. Early recognition of precancerous lesions and their treatment according to the author could prevent the occurrence of carcinoma in 50 to 75 per cent of the cases. Leucoplakia is considered the commonest precursor of lingual cancer. Epithelial carcinoma almost always begins as an overgrowth. It is only when ulceration develops in the form of a fissure that pain appears. A cancer of the tongue is a

crateriform ulcer forming an indurating mass. Cancer of the tongue should be expected when a persistent ulcer, chronic fissure, indurated epithelial wart, or advanced leucoplakia is present.

The presently popular subject of psychosomatic dentistry is given due consideration. It would be ludicrous to think, however, that one can eliminate dental diseases by undertaking the function of a neuropsychiatrist. While the psyche may be responsible for the initiation of complaints and for the severity with which pain is felt, there is nothing that the dentist can do in this respect unless he has special training. Contrarily, the somatic conditions of a dental nature must receive the attention and care of the practicing dentist.

A review of the prosthetic dental literature shows that we are passing through an era of restraint in the use of acrylic resins. Renewed interest has been shown in the construction of obturators for cleft palate patients.

In the section of orthodontics are reviewed many of the articles which originally appeared in the AMERICAN JOURNAL OF ORTHODONTICS AND ORAL SURGERY. Two articles are reviewed, one by Hartsook in which the point is made that mouth breathing has not been unequivocally proved to be a primary etiological factor in the production of malocclusion. This is followed by an article by Taylor in which nasal obstruction and associated mouth breathing are presented as etiological factors in dental deformities. We, unlike the editor of the section of orthodontics in the *Year Book*, find that a reading of the original article does not disclose assertions "entirely consistent with the opinions of Hartsook." Considerable space is given to the discussion of conditions affecting the temporomandibular joint. While diagnostic procedure in this respect has been greatly developed, the treatment still rests on a more or less trial and error basis.

As a method of keeping up to date on the more significant contributions to dental literature and as a reference text, *The Year Book of Dentistry* occupies a unique place in the library of the dentist. It is still the most for the money as far as dental books go.

News and Notes

Prize Essay Contest, American Association of Orthodontists

Eligibility.—Any member of the American Association of Orthodontists; any person affiliated with a recognized institution in the field of dentistry as a teacher, researcher, undergraduate or graduate student shall be eligible to enter the competition.

Character of Essay.—Each essay submitted must represent an original investigation and contain some new significant material of value to the art or science of orthodontics.

Prize.—A cash prize of $500 is offered for the essay judged to be the winner. The committee, however, reserves the right to omit the award if in its judgment none of the entries is considered to be worthy. Honorable mention will be awarded to those authors taking second and third places. The first three papers will become the property of the American Association of Orthodontists and will be published. All other essays will be returned.

Specifications.—All essays must be typewritten on 8½ by 11 inch white paper, double spaced with 1 inch margins, and composed in good English. Three copies of each paper, complete with illustrations, bibliography, tables, charts, etc., must be submitted. The name and address of the author must not appear in the essay. For purposes of identification, the author's name together with a brief biographical sketch which sets forth his or her dental and/or orthodontic training, present activity, and status (practitioner, teacher, student, research worker, etc.) should be typed on a separate sheet of paper and enclosed in a sealed envelope. The envelope should carry the title of the essay.

Presentation.—The author of the winning essay will be invited to present it at the meeting of the American Association of Orthodontists to be held in New York City, New York, May 2-6, 1949.

Final Submission Date.—No essay will be considered for this competition unless received in triplicate by the Chairman of the Research Committee on or before March 15, 1949.

ALLAN G. BRODIE, Chairman Research Committee,
American Association of Orthodontists,
30 North Michigan Avenue, Chicago 2, Ill.

American Board of Orthodontics

The 1949 meeting of the American Board of Orthodontics will be held at the Commodore Hotel, New York, N. Y., April 28, 29, 30, and May 1. Orthodontists who may desire to be certified by the Board may obtain application blanks from the Secretary, Dr. Stephen C. Hopkins, 1726 Eye Street, N.W., Washington 6, D. C.

Northeastern Society of Orthodontists

The Fall Meeting of the Northeastern Society of Orthodontists will be held at the Hotel Commodore, New York, N. Y., on Nov. 22 and 23, 1948.

Central Section of the American Association of Orthodontists

The regular annual meeting of the Central Section of the American Association of Orthodontists will be held Oct. 25 and 26, 1948, at the Corn Husker Hotel, Lincoln, Nebraska.

Great Lakes Society of Orthodontists

The Nineteenth Annual Meeting of the Great Lakes Society of Orthodontists will be held Oct. 18 and 19, 1948, at Hotel Statler in Cleveland, Ohio.

Dr. F. Copeland Shelden, Dr. Ashley E. Howes, Dr. B. Holly Broadbent, and Dr. Samuel Chase will be the essayists.

Table clinics will be presented. Time for fellowship is essential to all outstanding meetings. Please make your hotel reservations in ample time. We do not want you to be inconvenienced.

Southern Society of Orthodontists

The Southern Society of Orthodontists will hold its annual meeting Oct. 11, 12, and 13, 1948, at Hotel Peabody, Memphis, Tennessee.

Rocky Mountain Society of Orthodontists

The Rocky Mountain Society of Orthodontists will hold a two-day meeting Oct. 13 and 14, 1948, at the Cosmopolitan Hotel, Denver, Colorado. Dr. Spencer R. Atkinson of Pasadena, California, will be on the program both days.

New Edition, Orthodontic Directory of the World

The latest edition of the *Orthodontic Directory of the World* is off the press. Anyone not receiving his copy, or wishing the latest edition, please communicate with Dr. Oren A. Oliver, 1915 Broadway, Nashville, Tennessee.

Dr. Henry U. Barber, Jr.

It is with deep regret that we learn of the untimely death of Dr. Henry U. Barber, Jr., and Mrs. Pricilla Barber, who were killed in an automobile accident on Aug. 16, 1948. Dr. Barber, a former president of the American Association of Orthodontists, was 54 years old. He is survived by a son and a daughter. A suitable obituary notice will appear in an early issue of the JOURNAL.

Notes of Interest

Dr. Michael J. Frantz, Jr., announces the opening of his dental offices at 20881 Lorain Road, Cleveland 16, Ohio, practice limited to orthodontics.

Robert B. Hedges, D.D.S., M.S., announces the opening of an office at 703 West Avenue, Jenkintown, Pennsylvania, practice limited to orthodontics.

Dr. S. J. Kessler wishes to announce the association of Dr. Benjamin Rubin, 91 Lyons Avenue, Newark, New Jersey, practice limited to orthodontics.

John Rush McCoy, D.D.S., wishes to announce the association of Richard S. Hambleton, D.D.S., in the exclusive practice of orthodontics, 3839 Wilshire Boulevard, between Western and Manhattan, Los Angeles 5, California.

Dr. M. Albert Munblatt announces the association of Dr. Marvin A. Bregman for the practice of orthodontics, 310 Riverside Boulevard, Long Beach, New York, telephone Long Beach 6-0983.

Dr. B. E. Phillips, formerly of Salt Lake City, Utah, wishes to announce the removal of his office to Suite 1, 777 Bryant Street, Palo Alto, California, practice limited to orthodontics.

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The AMERICAN JOURNAL OF ORTHODONTICS AND ORAL SURGERY is the official publication of the American Association of Orthodontists and the following component societies. The editorial board of the AMERICAN JOURNAL OF ORTHODONTICS AND ORAL SURGERY is composed of a representative of each one of the component societies of the American Association of Orthodontists.

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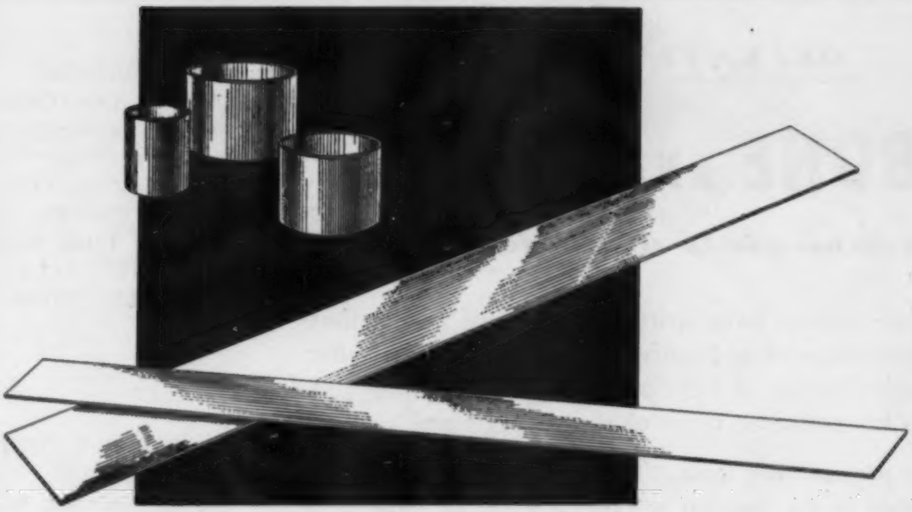

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